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PHYSICS.—*The beginnings of physics. II. The quest for creative concepts.*[1] RAYMOND J. SEEGER, The George Washington University.

Can any good thing have come out of Greece—as far as science is concerned? It seems to be fashionable among scientists to answer this question with a knowing smile. And yet, how much is our reply based upon deep understanding and how much upon superficial prejudice? This so-called ignorance of the ancients, is it not often merely a confession of our own ignorance of them? In this instance, indeed, it may be that in refusing to look beyond their quest for general principles we fail to catch a glimpse of their quest for creative concepts. For although it is an anachronism to speak of Greek concepts in the Newtonian sense, it is just as truly a libel to deny them in the Archimedean sense. And to neglect them altogether is to affirm that science sprang fully developed from the mind of the late renaissance like Minerva from the head of Jupiter, whereas even our most casual glance at history tells us that there is more continuity[2] in the evolution of human thought than we may have power or time to investigate. Now and then new types of reasoning do emerge, but these are invariably found to be old methods redefined, reorganized or reemphasized. There is never an immediate emancipation from the past. So, too, in science changes in the nature of physical concepts have consisted chiefly in sharper analyses of what have previously been taken for granted as self-evident truths. For example, Galileo[3] emphasized that the concepts of the Scholastics were meaningless without experimental tests. All the same, he retained space and time as part of his own instinctive logic. Centuries later Einstein[4] pointed out that even such ideas have to be associated with a set of metric operations, e.g., length signifies only those operations by which it is measured. (The identity

[1] *The beginnings of physics. I. The quest for general principles.* This JOURNAL **24**: 501. 1934. Part II received March 16, 1935.

[2] G. SARTON: *The history of science and the new humanism.* (1930) Chap. 1.

[3] GALILEO: *Dialogue concerning two new sciences.* (Translated by H. CREW and A. de SALVIO, 1914) p. 84.

[4] A. EINSTEIN: *The meaning of relativity.* (1923).
P. W. BRIDGMAN: *The logic of modern physics.* (1928).

of these with the ones used in the determination of time between widely separated points necessitates the single concept of space-time, which custom expediently divides into space and time—happily justified by the smallness of ordinary velocities as compared with that of light.) And now what Bohr[5] is stressing in his reciprocity-content of Heisenberg's uncertainty principle is the necessity of including, not only the methods, but also the very instruments in the scheme of things so that physical laws must be regarded both ideally and practically as probable descriptions of events indeterminate in space-time. One always used to assign all accidental errors of technique to the fictitious personal equation—often a convenient safety-valve. But the modern matrix formulation of quantum mechanics includes certain ones in real impersonal equations, which must be solved simultaneously with those giving the measured relationships. (Our everyday faith in causality is warranted only because the magnitude of the physical action usually involved is very much greater than that of Planck's quantum of action h.) Despite this changing significance, however, what never has changed has been the need of using the same kind of creative concept that Archimedes introduced in solving the problem of the king's crown.

As the story goes, King Hieron of Syracuse knew the royal goldsmith so well that he asked Archimedes (c. 287–212 B.C.) to ascertain the genuineness of a newly made gold crown without injuring it. Of course, the crown looked like gold and it felt like gold, but was it solid gold? Any direct test would be indecisive inasmuch as the crown might contain an unknown metal inside. What was needed was a property characteristic of materials and observable by indirect means. This restrictive generality led to the beginning of theoretical physics. For the fact that the head of the goldsmith was at stake meant that flimsy philosophizing would never do. There would have to be predicted some unique relation that could be determined practically. Any concept created from experiential appearances would have to be experimental in its outlook. And this is what we mean by a creative concept, namely, one that is adequately descriptive in its definition and experimentally significant in its relation to other concepts. One can hardly suppose that Archimedes analyzed his problem in this way—more likely he accepted all this intuitively. Yet it is really too bad that our usual picture of him is that of a nudist running down the street and panting "εὕρηκα." For his naïve haste from the most famous bath in history is apt to give us an impression of accidentality,

[5] N. BOHR: *Atomic theory and the description of nature.* (1934).

whereas it signified the enthusiastic climax of his quest for a creative concept. One might more profitably view Archimedes actually taking his bath in his customary listless fashion. Certainly he was doing more thinking than bathing as is evidenced by Plutarch's[6] report that occasionally he had to be carried by absolute violence to bathe. But his phenomenal success is not to be attributed solely to his genius. Scattered in the historical background were isolated cases of experiments and a continuous growth of mathematics. What he did was to unite these two methods by giving mathematical proofs for mechanical practices, thereby producing that powerful, but strange, approach to nature, mathematical physics (much to the disgust of Plato, who looked upon matter as being in the form of imperfect images of perfect ideals). For this reason Archimedes has been rightly called the *Newton of antiquity*. We shall now examine some of these antecedents of his work.

An experiment consists primarily of observation, measurement and repetition; in so far as these are controllable, the experiment is said to have good precision. It is possible to show that the development of the individual sciences can be interpreted in terms of their ability to obtain concepts that can be thus determined precisely. For this enables the power of the mathematical reasoning inherent in economic symbolism to be utilized in obtaining new relations among the concepts, which, in turn, may serve as a system of *checks and balances* or indicate new fields for planned research. Now the real failure of Greek science lay in its lack of such precision. It was not that no fine observations were made or that only crude measurements were attempted, but that the experiments were seldom repeated. For it is in the lack of controllability that the importance of neglected factors is often revealed so that an accurate method may not produce good results because of its wanting precision. By way of illustration, suppose someone measured the pressure of various volumes of a given mass of gas. He might find that it increased with decreasing volume. On the other hand, another observer might note a decrease. And both could be true, because the possibility of the influence of an additional factor had not been considered, viz., the change in temperature. Of course, if only one factor is variable, lack of discrimination is of no great moment. The following is an example of such a fortunate occurrence in Greek investigation.

Just how Pythagoras of Samos (fl. 532 B.C.) discovered the relation between the frequency of sound and the length of the string producing

[6] *Plutarch's Lives* : *Life of Marcellus.*

it is largely a matter of conjecture. Perhaps, he received his information from the priests[7] of Egypt while he lived there. On the other hand, the tradition of his conscious use of the experimental method gains credence when we recall that he made a science out of arithmetic by transferring it from the tradesmen's abacus to the philosophers' papyrus. (And what better example of how he molded *the queen of the sciences* out of the mud along the Nile than the Pythagorean theorem which generalized the 3–4–5 rule-of-thumb?) According to a popular story, as he was passing a blacksmith shop one day, he was impressed with the different musical notes that were emitted when the hammers struck the anvils. Observing that the hammers differed only in size, he surmised that the strings of the lyre might owe their harmony to their various lengths. Much to his surprise, he found that strings with lengths in the ratios 12:8:6 produced tones bearing musical relationships with one another. With the ratio 12:6 the longer string gave a tone an octave below that of the other; the ratio 8:6 was found to correspond to the musical interval of a *fourth*, and the ratio 12:8 to that of a *fifth*. Indeed, all the tones of the lyre could be thus expressed as simple numerical ratios of a single fundamental one. It was only natural that this fact should be exploited at a time when general principles were being sought in every particular phenomenon. The distinctive contribution of the Pythagoreans in this regard was that theirs was a quest for unity in form rather than in matter itself. Their search for the basic design of the universe was in the domain of numbers. How easily geometry was included in its scope! For had not a cube 12 edges, 8 corners and 6 faces? How readily astronomy fitted in the scheme; for there were 7 planets (including the sun and the moon at that time) corresponding to the seven strings of the lyre! Moreover, each of these was supposed to emit a divine note as its celestial sphere rotated. This unheard music of the spheres inspired much thought and contemplation, e.g., Kepler's *Harmonice Mundi* with his celebrated harmonic law (third). Even matter was found to be susceptible of classification according to this principle of number; for the four regular solids, namely, tetrahedron, octahedron, icosahedron, cube, were looked upon as symbolizing the four elements fire, air, water and earth respectively. (The later discovery of the last regular solid, the dodecahedron, was embarassing until someone realized that it signified the whole universe.) How far these awe-inspiring analogies could be carried became a problem for philosophers, and not for mere

[7] H. HELMHOLTZ: *On the sensations of sound.* (3rd ed. 1895, translated by A. J. ELLIS.) p. 1.

physicists. The fact remains, however, that there have been other consequences more important than these unwarranted speculations. One is the famous quadrivium of early medieval education: absolute numbers (arithmetic), applied numbers (the studies presided over by the nine muses—called collectively music), magnitude at rest (geometry), magnitude in motion (astronomy). Furthermore, the search for simple numerical relations has played no mean rôle in the formulation of modern physical theories. More than once a hypothesis has been rejected or accepted on the basis of the simplicity of its mathematical formulation. For instance, the experiments of Regnault were even questioned at one time because they did not conform to the simple law of Boyle and of Mariotte. The early rejection and later acceptance of Prout's hypothesis (1815), that all atomic weights are integral, reminds us of the powerful demand for simple numerical regularities. And so we must ever be on guard that our science does not distort its reflected view of nature, that it does not substitute its own convenient simplicity for nature's incomprehensible multiplicity, that it does not altogether hide synthetic processes behind its analytic harmony. To illustrate, what accounts for the universality of simple harmonic motion? Is nature characteristically simple and harmonic? On the contrary, this arises from the customary procedure of neglecting higher order terms of the Taylor expansion of the potential energy about a position of equilibrium—justifiable for small displacements only. Hence, we have to beware always of the fatalistic mysticism of numbers, as the later history of the Pythagorean school itself revealed. It is significant, however, that mathematics and experiment should have been so closely associated at the beginning of physics. For without experiment mathematics is physically meaningless and without mathematics data are physically incomprehensible. In other words, it is equally difficult to listen to someone speak in an unknown language as it is to hear one converse incoherently about this and that. What makes facts worthwhile is their ordering, not their almanac-like compilation. As Poincaré[8] has so well expressed the idea: "Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house." Indeed, we would go one step further and say that it is no more a mere organized collection than a house is a home. The human spirit broods over the chaotic facts of nature until they warm with cosmic life. Creative concepts make science a functioning organism as well as a mechanical organization.

[8] H. POINCARÉ: *Foundations of science.* (Reprint 1929, translated by B. HALSTAD.) p. 27.

Other experiments that are recorded dealt with the proof of the corporeality of air—a fact first suggested by Anaximander, but disregarded by Anaximenes. (Cf. Voltaire's[9] erroneous notions about air a century after Boyle's work.) In the fourth book of Aristotle's *Physics*[10] we find such experiments described. One due to Anaxagoras demonstrated "that air is a physical substance by inflating bladders and showing their strength of resistance to compression." A second, that of Empedocles, pointed out the same conclusion by means of a water-clock, i.e., an open vessel with a small hole in the bottom for the water to flow. Suppose the vessel is emptied and inverted in a container of water, while one's finger is held over the aperture. The water will not rise owing to the presence of the air. These experiments are particularly remarkable in that they were cited to refute specific fanciful speculations.

We turn our attention again to the rapid development of mathematics which preceded the work of Archimedes, the *greatest mathematician of antiquity*. Although Socrates' (c. 470–399 B.C.) *theory of ideas* was of little value to the direct study of matter, it replaced ingenious sophisms with reasoned proofs and thereby stimulated mathematical investigations because of its emphasis on form. For example, consider the triangle. Regardless of its size, shape or substance it always has the sum of its angles equal to 180° (in Euclidean space). Thus universal truths can be reaped without the chaff of incidental conditions. Now the history of physics itself can be said to be a continual search for just such generality. At the time of Socrates, however, its great significance was chiefly its stress upon a rational reality that was not materialistic; hence, it was not many years before mechanics joined mathematics as an abstract study. Properly speaking, we should say that the seed of the *theory of ideas* was planted by Pythagoras and that its cultivation in moral and aesthetic fields was the special task of Socrates. The Academy of Plato (c. 428–348 B.C.), who was intimately acquainted with the Pythagorean, Archytas of Tarentum, utilized it in mathematics. Nevertheless, Plato's main interest in this subject lay in the educational value of its clear-cut definitions and of its rigorous reasonings in the training of philosophers. Above his porch was the following inscription for those entering: "Let none that is ignorant of geometry enter my doors!" But nothing was said about the mathematics of those leaving. What his method accom-

[9] *Oeuvres complètes de Voltaire* (Firmin-Didot 1874) 7: 41–45.
[10] ARISTOTLE: *The physics*. (Translated by P. WICKSTEED and F. M. CORNFORD 1929) Book 2, Section 6.

plished, therefore, was more the development of mathematical interest than of interesting mathematics. (His physics was worthless, as may be appreciated by reading his *Timaeus*.) This impetus given to the study of mathematics led gradually to its divorce from philosophy so that mathematics was finally studied for the sake of mathematics. This was particularly true in Alexandria where cosmopolitan influences minimized irrelevancies in the search for truth. In the famous museum of this city (c. 300 B.C.), dedicated to the Muses, began a period of investigation that is outranked only by the modern era. Indeed, the *Elements* of Euclid, i.e., 13 books on geometry, have survived as have few other works. Their pedagogical discipline has been of inestimable value owing to the author's synthetic method of deducing his theorems from certain definitions, postulates and axioms set out at the start. Although modern geometers reject the unique validity of the fifth postulate of Book I (the so-called parallel postulate), they are still indebted to Euclid for showing how any single geometry has to be constructed logically. The immediate effect of the *Elements* was to mold the form of the Mechanics of Archimedes of Syracuse, the foremost thinker of the Alexandrian school.

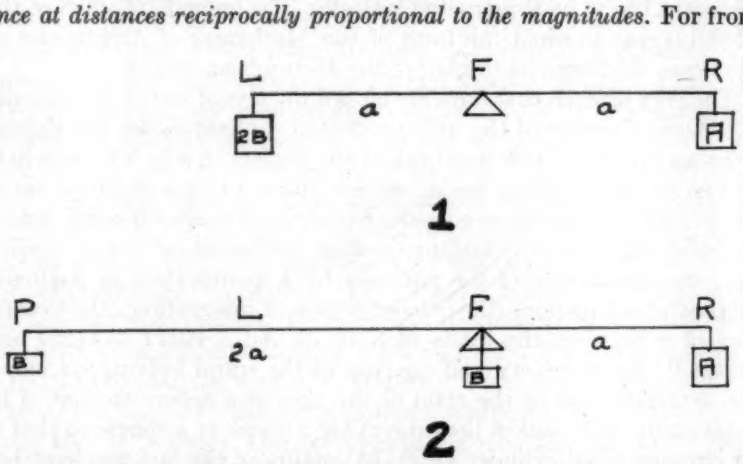
The very legends that have enveloped the inventions of Archimedes (Cf. Lucian's story of the use of reflected sunlight to set the Roman ships on fire) are a measure both of the respect in which he was held and of his genius. Even to-day we are amazed at his powerful use of mathematics. In order to consider his physical studies in some detail, we shall only mention his outstanding mathematical contributions: viz., the quadrature of the parabola by a modification of Eudoxos' method of exhaustion, (the primitive form of integration), the evaluation of π between the limits of 3 10/70 and 3 10/71 (3.14287 and 3.14083), the discovery and analysis of the spiral bearing his name, the determination of the ratio of the area of a sphere to that of its great circle (4:1) and of the ratio of the volume of a sphere to that of its circumscribed cylinder (2:3). (A picture of the last was sketched upon his tomb at his own request.) It is important to realize that these high mathematical attainments made it possible for him to solve such a physical problem as the equilibrium of a right segment of a paraboloid of revolution immersed in a liquid, and that he was here concerned with a creative concept, the center of mass. The substitution of a symbolic mass-point for an irregular solid had already been used previously in practice, but was first computed mathematically by Archimedes for a parallelogram, triangle, trapezium, and a parabolic segment. Moreover, all these proofs were based on the law of the

lever so that he first had to derive the law in a way which we shall now consider.

All his proofs follow the method of Euclid in the postulation of self-evident truths. The first three of the seven postulates that head the first book,[11] *On the equilibrium of planes*, are as follows:

> (1) "Equal weights at equal distances are in equilibirum, and equal weights at unequal distances are not in equilibrium but incline towards the weight which is at the greater distance."
>
> (2) "If, when weights at certain distances are in equilibrium, something be added to one of the weights, they are not in equilibrium but incline towards the weight to which the addition was made."
>
> (3) "Similarly, if anything be taken away from one of the weights, they are not in equilibrium but incline towards the weight from which nothing was taken."

These are used in propositions 6 and 7 to deduce the law of the lever, i.e., *Two magnitudes whether commensurable or incommensurable balance at distances reciprocally proportional to the magnitudes.* For from



Figs. 1–2.—Illustrations used in Archimedes' derivation of the law of the lever.

(3) follows the converse of (1), viz., that weights which balance at equal distances are equal. Otherwise, it would be possible to remove the excess weight and have equilibrium, which is absurd on the basis of the principle of sufficient reason and symmetry (the essential reason for the first part of postulate 1). We shall now use this conclusion to illustrate Archimedes' reasoning for the simplest case of one weight

[11] T. L. HEATH: *The works of Archimedes.* (1897) p. 189.

A being double another weight B. First suppose two weights A and $2B$ are in equilibrium (Fig. 1) at the same distance from each side of the fulcrum. Then they are equal, i.e. $A=2B$. Now divide one of the weights, say the one $2B$ at L, into two equal parts B and transfer each of these in opposite directions to a distance a from L (Fig. 2). These two weights B are symmetrically located with respect to L and therefore are in equilibrium (postulate 1), but their center of mass at L is still in equilibrium with the weight at R. Thus the entire system remains in equilibrium after the displacement. The weight B at F, however, can now be removed inasmuch as it is supported by the fulcrum. And so B balances A at a distance twice as great as $2B$ did. This method can be easily generalized to include any case.

Mach[12] has pointed out that the above reasoning is fallacious as far as proving something new is concerned. Criticisms[13] of Mach's views notwithstanding, it would be surprising if the mere knowledge of the variables, weight and length, were sufficient to determine their functional combination. Where, then, is this relationship assumed in the proof? It is assumed in the displacement from L. For this involves the tacit assumption that weight and length each enter in the condition for equilibrium only in the first degree. Suppose the law were of the second degree. In the set-up of Fig. 1 we have for equilibrium

$$Aa^2=Aa^2$$

But the positions in Fig. 2 give for equilibrium

$$A/2(a+a)^2+A/2(a-a)^2=Aa^2.$$

or

$$2Aa^2=Aa^2.$$

On the other hand, if the law is of the first degree, the second case gives

$$A/2(a+a)+A/2(a-a)=Aa$$

or

$$Aa=Aa.$$

In other words, it is the use of the concept of center of mass with its inherent linear distribution that makes the displacement possible and this is an application of the very law of the lever which we started

[12] E. MACH: *The Science of mechanics.* (4th ed. 1919, translated by T. J. McCORMACK.) Chap. 1.

[13] C. SINGER: *Studies in the history and method of science.* (Contains an essay by J. M. CHILD entitled *Archimedes' principle of the balance and some criticisms upon it*) 2: 490.

out to deduce. We have completed a vicious circle with all the dignity of logic. Where did we first err? The fact is that the basic law of statics is experiential and occurs in nature in many equivalent forms; it must be implied in any proof that deals with observed relations. Despite the sanity of expecting to discover experiential laws only in actual phenomena, thinkers have been attacked by a mania for Euclidean demonstrations again and again. They have made many attempts to ascertain the fundamental law of statics, e.g., they have discussed the meaningless question as to whether the law of the lever is more basic than the law of the inclined plane. Yet reversible demonstrations show that these are equivalent and only emphasize their essential similarity. If theory demands definite postulates as starting places, truth itself is insufficient as the criterion for them. It was many years, however, before *convenience*[14] came to be recognized as the basis of selection, and John Bernoulli's principle of *virtual work* was finally accepted in this sense as the fundamental one from which the specific laws of statics are to be obtained. It is noteworthy that Archimedes had in his grasp the necessary conditions for such equilibrium, viz., the balancing of forces and their lever-like distribution. And yet, what is most significant about Archimedes is that he appreciated the extrapolation of his laws to elements beyond his immediate experience; he used his concept to predict. This is epitomized in his boast: "Give me a place to stand on, and I will move the earth." And he actually did move Marcellus' attacking army with his huge levers in the forms of catapults, etc.

We have already mentioned his classic work on hydrostatics. He began the first of his two books *On floating bodies*[15] with the following definition of a fluid: "Let it be supposed that a fluid is of such a character that, its parts lying evenly and being continuous, that part which is thrust the less is driven along by that which is thrust the more; and that each of its parts is thrust by the fluid above it in a perpendicular direction if the fluid be sunk in anything and compressed by anything else." Then in proposition 7 he probably gave his method of solving the problem of the crown, viz., "A solid heavier than a fluid will, if placed in it, descend to the bottom of the fluid, and the solid will, when weighted in the fluid, be lighter than its true weight of the fluid displaced" (Archimedes' principle). Let us apply this to the problem of the crown. Consider a lump of gold having the same weight as the crown in air. Weigh the gold and the crown in

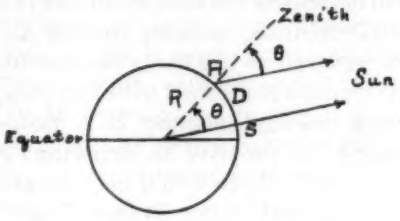
[14] H. POINCARÉ: op. cit. pp. 106, 125, 173, 208.
[15] T. L. HEATH: op. cit. p. 253.

water separately and compare their losses in weight. If the crown is made of pure gold, it will have the same loss of weight as the gold lump. The basic concept employed is specific gravity, i.e., the ratio of the weight of a body in air to that of an equal volume of water; hence, the problem can also be solved by the direct consideration of density, or rather, its reciprocal, specific volume, for different substances of the same weight have different volumes. Thus the volume of the displaced water can be used to determine the composition of the crown. This is the method Vitruvius[16] mentions as being the one Archimedes used. This interpretation seems to us less likely because no proposition in Archimedes' works is directly concerned with this idea, whereas, proposition 7 is proved in a thorough manner. It is inconceivable that he would have omitted the proof of so important a method. It might appear that the fact of the bath would help answer this dilemma. In either case, however, he could have obtained a critical clue from the water. The first method would have been assisted by his surmising that the buoyant effect of the water varied characteristically with different materials (for the same weight of substances). On the other hand, the difficulty with the second method was the determination of the volume of the highly ornamented crown. The overflow of the water might have suggested the way to obtain this from immersion of the crown in a full vessel. At any rate, in both cases the essential feature was the need of a concept that was adequate because of its uniqueness and its generality as well as the additional factor that it had to be creative, i.e., it had to predict, directly or indirectly, a practicable experiment. Obviously, a concept, such as characteristic shapes of the atoms, would have been useless because of their indeterminacy. We note also the intuitive use of the factor of simplicity in that the specific gravity was used and not the sum of its square and its cube root, which, nevertheless, satisfies all the other demands. The consummate skill of Archimedes rested in his ability to choose a simple creative concept.

We shall briefly mention some of the inventions of the period before considering the later activities of the Alexandrian school. To Archytas is credited the pulley and the screw (also a child's rattle that Aristotle recommended as something good to keep children from breaking things about the house); to Archimedes is credited the endless screw, the hydraulic screw and the compound pulley; to Ctesibios of Alexandria, the force-pump, the hydraulic clock and the hydraulic organ; to Heron of Alexandria, a steam-engine, a siphon and many automatic

[16] M. VITRUVIUS: *De Architectura*. Book 9, Section 3.

devices. Of greater scientific interest is the ingenious determination of the diameter of the earth by Eratosthenes of Cyrene (c. 273–192B. C.), who was a librarian of the Museum. (The Pythagoreans had already introduced the globular form of the heavenly bodies because of the simple perfection of the sphere.) His method consisted of determining the distance D between two cities on the same meridian,



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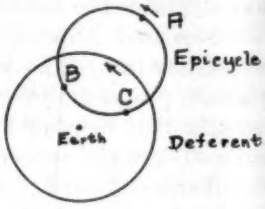

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Fig. 3.—An illustration of Eratosthenes' method of determining the diameter of the earth. Fig. 4.—An illustration of Apollonios' epicycle description of the motion of the planets.

Meroe (near Alexandria) and Syene, and then observing the angle the sun's rays made with the zenith at the former when the sun was at the zenith of the later (Cf. Fig. 3). This angle was the same as that subtended by the radii to these points. Consequently, the radius R could be determined from the relation $D = R\theta$. The observed data[17] were $D = 5040$ stades and $\theta = 7°15'$. The ancient use of different values of the stade in various localities makes it impossible to check the accuracy absolutely to-day. On the basis of the stade[18] being equal to 516.73 feet, the polar diameter was 3925 miles as compared with the modern value of 3949.99 miles. The importance of this method is its use of quantitative observation. This was exemplified even better later by another Alexandrian, Claudios Ptolmaeos (c. 138 A.D.), whom Sarton[19] praises as having performed "the most remarkable experiment in antiquity." It was a study of the refraction of light.

Although the rectilineal propagation of light was well-known to Euclid and inevitably aroused his interest because of its applicability to the geometry of perspective, his *Catoptrics* revealed either a poor account of what he did know or else a good account of what he did not

[17] *Geographica Strabonis.* (recognovit A. MEINEKE 1866) 1: Book 2.
[18] J. L. E. DREYER: *History of the planetary systems.* (1906), p. 175.
[19] G. SARTON: *Introduction to the history of science.* (1927) 1: 274.

know. It was Heron who noted the law of reflection and proved that it was equivalent to the principle of the shortest optical path (Cf. Fermat's Principle of Least Time). The search for the law of refraction was made by Ptolemaeos by a method quite different from that of Archimedes. The latter deduced observable relations from postulates;

TABLE 1.—PTOLEMAEOS' DATA FOR HIS LAW OF REFRACTION

ANGLE OF INCIDENCE (i)	ANGLE OF REFRACTION (r)	i/r[a]	$\sin i/\sin r$[a]
	(1) AIR TO WATER		
10	8	1.25	1.25
20	15.5	1.29	1.28
30	22.5	1.33	1.31
40	29	1.38	1.33
50	35	1.43	1.34
60	40.5	1.48	1.33
70	45.5	1.54	1.32
80	50	1.60	1.29
		Average	1.31
	(2) AIR TO GLASS		
10	7	1.43	1.43
20	13.5	1.48	1.46
30	19.5	1.54	1.50
40	25	1.60	1.52
50	30	1.67	1.53
60	34.5	1.74	1.53
70	38.5	1.82	1.51
80	42	1.90	1.47
		Average	1.51
	(3) WATER TO GLASS		
10	9.5	1.05	1.05
20	18.5	1.08	1.08
30	27	1.11	1.10
40	35	1.14	1.12
50	42.5	1.18	1.13
60	49.5	1.21	1.14
70	56	1.25	1.13
80	62	1.29	1.12
		Average	1.11

[a] Computed by the author.

the former arrived at laws from observable data. Thus we have the beginning of the application of the inductive method in science in addition to the deductive one; to-day both are still necessary, neither is sufficient alone. And yet, as is well known, Ptolemaeos failed to obtain the correct form of the law, which was discovered much later by Snell. We emphasize the word form; for the data of Ptolemaeos was not at fault (Cf. Table)[20a]. His failure was partly owing to the fact

[20] *L'Ottica di Claudio Tolomeo da Eugenio.* Riddotta in Latino (pubblicata da G. Govi 1885) a. Sermo Quintus, b. Introduzione.

that his trigonometric functions were crudely defined and partly to the fact that he was intent upon getting a simple law. As Govi[20b] has shown, his data conform more to a law of the quadratic type than to a simple proportion, e.g., $r = a\,i + b\,i^2$, where i is the angle of incidence, r the angle of refraction and b a constant much smaller than the constant a so that the second term is negligible for small angles. All in all, Ptolemaeos was not far from modern science. It is in the field of astronomy, however, that his creative power is best known inasmuch as his *Almagest* (Μεγίστη Σύνταξις) with its complete Ptolemaic system became the embodiment of Aristotelian cosmology. To understand its scientific significance we turn back to the interest aroused in this branch of applied mathematics by Plato.

Up to the time of the Attic philosophers the chief astronomical problem had been to account for the diurnal motion of the sky and was usually solved by the hypothesis that the stars and the planets were attached to a rotating sphere. In the Pythagorean scheme, however, a daily revolution of the earth was supposed to take place about a primordial fire-center (not the sun), which was never seen on account of an interposed counter-earth. Both of these explanations failed to take cognizance of the irregular motions of the planets. So Plato proposed the problem to his students with the hint that they use "uniform and ordered" motions in its solution. Eudoxos, the originator of the *method of exhaustion*, which was the ancient analogue of the modern theory of limits (Cf. Euclid: Book XII), gave an ingenious geometric answer. He considered every celestial body to be on the equator of an individual sphere rotating uniformly about its polar axis. To account for the retrograde and latitudinal motions of the planets, he further assumed that the poles of these planetary spheres were also attached to a sphere concentric with the first, but rotating with a different angular velocity about a differently directed polar axis. Since these still proved to be inadequate for the description of the observed motions, other spheres were similarly introduced so that four spheres in all had to be associated with each of the planets and three with either the sun or the moon. (All these spheres were to be regarded as independent of one another.) Finally, one additional sphere was necessary for the entire group of fixed stars. This purely kinematical approach to astronomical motions was the forerunner of other nondynamical theories that held sway for many years because of their adequate description. One of these was suggested by Calippos of Cyzicos (n. 370 B.C.), who added a sphere in each case for Mars, Venus and Mercury as well as two for the sun and two for the moon.

The ones for the planets were to produce retrogression without altering appreciably the synodic period, i.e., the time between successive conjunctions of the sun and moon. In the case of the sun the spheres were necessary to describe the unequal lengths of the seasons, which had been noted in 432 B.C. by Meton and Euctemon at Athens. The most startling modification, however, was made by Aristotle (c. 384–322 or 321 B.C.). Lacking the insight of the mathematician he insisted upon having real mechanical spheres in contact with one another. And then in order to prevent the motion of the sphere of an outer planet from being communicated to that of an inner one, he had to add a few more spheres—22 in all. Thus Aristotle's theory required 55 spheres for the heavenly bodies as compared with 34 for that of Calippos and 27 for that of Eudoxos. The system was becoming too cumbersome. Fortunately, its abandonment was hastened by the discovery that the planets appeared brighter at times, as if they moved closer to the earth. No system of rigid spheres was sufficiently flexible to permit this so that about all that could be retained of the Aristotelian system was its geocentricity, nevertheless, his authority in this particular outweighed the geoheliocentric proposal of Heraclides of Pontos (c. 388–315 or 310 B.C.), i.e., that Mercury and Venus revolved about the sun while it revolved with the other bodies about the earth (Cf. Tycho Brahe's extension of this, that all the planets revolved about the sun, which revolved about the earth). Indeed, even the complete Copernican-like hypothesis of Aristarchos of Samos (fl.c. 280 B.C.) had to wait for Copernicus to expound its daily rotation of the earth and its increased size of the universe to account for the fixedness of the stars. This delay was assisted by the epicyclic theory stressed by another astronomer, Hipparchos of Nicaea (c. 136 B.C.), who noted also a 48″ advance or precession of the equinoxes each year (the modern value is about 50″).

Apollonios of Perga (c. 260–200 B.C.), *the great geometer*, who wrote eight classic books on conic sections, first applied epicycles to astronomy. Their value in the description of planetary motions is evident on examination. Consider a planet moving on a circle (the epicycle) with a period of one sidereal year while the center of this circle, in turn, moves in the same sense on another circle (the deferent) with the period of the planet's revolution. At some points B and C (Fig. 4) the motions will annul each other so that the planet will appear at rest. From C to V via A the motion will be progressive with an increase of speed from C to A and a decrease from A to B. From B to C the motion observed on the earth will be retrograde. In this way the motions

of the outer planets can be explained qualitatively. For the planets Mercury and Venus the deferent was given the period of the sidereal year and the epicycle that of the revolution (about the sun on the modern view). As for the sun and moon, which do not show retrograde motions, the motion on the epicycle and that on the deferent were considered to be in the opposite sense. Moreover, the hypothesis of eccentric circles was found to be so useful in describing certain irregularities that Hipparchos used it to fully explain the motions of the sun and the moon. But his greatest contribution was not so much his use of epicycles as it was the beginning of accurate observations that were carried on for three centuries and were thus available for later theoretical study. Indeed, the distinguishing feature of the system of Ptolemaeos was the making of the deferent eccentric in the case of the moon and the five planets. Various minor corrections that also had to be made, need not concern us in our present discussion.

It is particularly important to interpret the Greek attitude to this system correctly. It was not regarded even by Ptolemaeos himself as an actual representation of the planetary motions, but it was considered merely a means of computing the positions of the planets at future times; it was a creative concept. The cumbersome geometry had to be employed in lieu of any algebra at all.

In conclusion, we would emphasize the unmistakable direction that the Alexandrian school pointed out to the early seekers of knowledge, viz., mathematical analysis applied to concepts for the purpose of experimental predictability. That this quest for creative concepts was pursued more in astronomy than in physics was owing to the fact that the former was free from the entangling preconceptions and the snarling misconceptions of philosophy, whereas the latter retained intimate relations with philosophical speculations. Later the pressure of mind as superior to matter stifled physics completely. And yet, we must be careful not to disparage the thought of an age by considering its thinkers as indeterminately banded together. For the brilliant torch of research has been handed down in the main from individual to individual, from group to group, without regard to popular pluralities. Hence, the contributions of Greece to the development of physical concepts should be measured by the blazing peaks her pioneers discovered and not by the dark lowlands in which their associates rambled.

PHARMACOLOGY.—*The toxicity of sodium cyanide and the efficiency of the nitrite-thiosulphate combination as a remedy for poisoned animals.*[1] A. B. CLAWSON, JAMES F. COUCH, and H. BUNYEA, Bureau of Animal Industry.

The poisonous qualities for sheep of potassium cyanide and of hydrocyanic acid have been discussed briefly in former papers and the results that may be expected by treating the poisoned animals with sodium nitrite and sodium thiosulphate in combination have been pointed out.[2] More recently the writers have had an opportunity of testing the toxicity of sodium cyanide for sheep and the nitrite-thiosulphate combination as a remedy for animals poisoned by it. It is proposed in this paper to present the results of tests with sodium cyanide and briefly to compare them with similar results obtained in the experimental work with potassium cyanide and with hydrocyanic acid. Such a comparison seems especially fitting as the animals used in the experiments with the different cyanides had been subjected to very similar conditions and during the respective investigations were handled in the same way.

TOXIC AND LETHAL DOSES OF SODIUM CYANIDE

In determining the toxic and lethal doses of sodium cyanide, when administered as a drench in a water solution, 17 experimental tests were made on 14 sheep. The dosages and results are shown in table 1.

TABLE 1.—QUANTITIES OF SODIUM CYANIDE GIVEN TO SHEEP IN A DRENCH AND THE EFFECTS PRODUCED WHEN NO REMEDIES WERE USED.

Date 1935	Sheep		Quantities[a] given and effects produced		
	No.	Weight kg.	Symptoms	Sickness	Death
Jan. 19	1457	34.92			34.66
19	1453	36.73			34.30
19	1482	38.55			32.69
19	1474	37.64			13.95
14	1467	53.06			5.78
14	1471	31.75			5.56
16	1472	39.91			5.32
18	1479	29.02			5.28
14	1468	42.63			5.22
18	1453	36.73		5.20	
18	1476	37.64			5.19
16	1466	35.83		5.10	
18	1469	43.99			4.92
16	1454	46.49	4.82		
14	1466	35.83	4.63		
16	1453	36.73	4.57		
16	1455	30.84	4.15[b]		

[a] The quantities are given as milligrams of sodium cyanide per kilogram of animal's weight.
[b] Symptoms very mild, consisting only of a stimulation of the respiration.

[1] Received March 26, 1935.
[2] This JOURNAL 24: 369–395, 528–532, 1934; 25: 57–59, 272–276; 1935.

One sheep was used three times and one was used twice. Each of the other animals was used in a single experiment. In 7 additional cases a solution of 1 gram of sodium nitrite and 2 grams of sodium thiosulphate in 15 c.c. of water was injected intraperitoneally at periods ranging between 1.5 and 4 minutes after the cyanide was administered. These are shown in table 4.

The sodium cyanide solution was carefully prepared and checks made so that each c.c. of solution contained 21.003 mg. of sodium cyanide equal to 11.147 mg. of the cyanide radical (CN), or the equivalent of 11.575 mg. of HCN.

In all cases the dosages were computed as milligrams of sodium cyanide per kilogram of animal weight.

As shown in table 1, a quantity of sodium cyanide equivalent to 4.15 mg. per kg. of animal weight was the smallest dose given. As the effects were very slight, consisting of a mild stimulation of the respiration, and as somewhat larger doses gave correspondingly more marked results, this quantity (4.15 mg. per kg.) is evidently very close to the minimum toxic dose.

The minimum lethal dose is somewhat in doubt, but evidently is close to 5.22 mg. per kg. of animal weight. Sheep 1468, the animal killed by this quantity; sheep 1479, killed by 5.28 mg., and sheep 1476, killed by 5.19 mg., had received no previous drenchings of cyanide. As compared with these, sheep 1453 made sick by 5.20 mg., had been poisoned three times previously by cyanide, the last time on January 17, when it had been given 3 m.l.d. of hydrocyanic acid, followed by an intraperitoneal injection of the nitrite-thiosulphate combination, and sheep 1469 which died following the administering of 4.92 mg. had been given two previous doses of 3 m.l.d. each of hydrocyanic acid, followed by the nitrite-thiosulphate combination. It is possible, although not clear, that the previous treatment may have somewhat modified the results. It is evident that the m.l.d. does not exceed 5.22 mg. per kg. of animal weight.

COMPARATIVE TOXICITY OF CYANIDE WHEN GIVEN IN DIFFERENT FORMS

For comparison with potassium cyanide and hydrocyanic acid, the minimum toxic and minimum lethal doses are given in table 2. In this table the dosages are given in terms of the substances actually administered and of the cyanide radical (CN) equivalents.

Based on the smallest quantities of the substances themselves that produced visible effects, hydrocyanic acid, potassium cyanide, and

TABLE 2.—RELATIVE QUANTITIES[a] OF KCN, HCN AND NaCN REQUIRED, WHEN GIVEN AS A DRENCH, TO PRODUCE SYMPTOMS IN AND TO KILL SHEEP.

Substance given	Minimum toxic dose		Minimum lethal dose	
	As substance given	As CN equivalent	As substance given	As CN equivalent
HCN	1.05	1.01	2.29	2.20
KCN	2.43	.95	5.57	2.23
NaCN	4.15	2.20	5.22	2.77

[a] Dosages given as milligrams per kilograms of animal weight.

sodium cyanide bear the approximate relationship represented by the values 1:2.3:4. That is, sodium cyanide is one-half as toxic as the potassium salt and one-fourth as toxic as hydrocyanic acid. If considered on the basis of their cyanide equivalents, their ratio is 1:1:2.2.

The ratios for the minimum lethal dose are somewhat different, being 1:2.4:2.3, when based on the substances actually administered, and 1:1:1.26, if based on the cyanide equivalent. Apparently sodium cyanide is less poisonous than either hydrocyanic acid or potassium cyanide, while there is no appreciable difference between the two latter forms.

The relationship between minimum toxic and minimum lethal doses of the three forms differ somewhat. For hydrocyanic acid and potassium cyanide the relationship is nearly the same, it being approximately 1:2 in both cases. For sodium cyanide it is close to 1:1¼. That is, with HCN and KCN, about twice as much is required to kill as to produce visible effects, while with sodium cyanide the lethal dose is only about 25 per cent greater than the minimum toxic dose.

As the efficiency of any remedial measures in cyanide poisoning is closely related to the promptness with which it is given, or, more correctly, the stage of illness when it is administered, a comparison of the rates at which the stages of poisoning develop when the different forms of cyanide are administered is of considerable interest. The various stages overlap so that no actual sharp boundary exists between them. In most cases, however, three points could be determined fairly closely. These are: (1) symptoms, or the time when the respiratory movement began to show the effect of stimulation; (2) collapse, or when the animals fell and were unable to get to their feet; and (3) death. Considering the cases in which fairly accurate observations were obtained, and eliminating such as were influenced by the administration of remedies, averages, times between the giving of the cyanide and the appearance of the effects, were obtained. These are shown in table 3.

TABLE 3.—SHOWING THE TIME FROM THE GIVING OF CYANIDE IN THE THREE FORMS (HCN, KCN, AND NaCN) AND VARIOUS EFFECTS.

Form in which given	Effect	No. of cases	Time to effect					
			Minimum		Maximum		Average	
			Min.	Sec.	Min.	Sec.	Min.	Sec.
Hydrocyanic acid	Symptoms	28		20	2			50
	Collapse	23		50	51	30	5	52
	Death	11	12	30	51	46	30	16
Potassium cyanide	Symptoms	79		30	3	00	1	7
	Collapse	80		30	23	00	2	46
	Death	13	6	00	56	00	25	49
Sodium cyanide	Symptoms	24		30	1	45	1	00
	Collapse	18		30	9	50	2	59
	Death	11	8	00	90	00	34	39

Although table 3 is based on too small a number of cases for positive conclusions, it furnishes certain information. The form in which the cyanide is administered as a drench in water solution has no significant influence on the time it takes symptoms to develop. Apparently the time to collapse is somewhat longer when hydrocyanic acid has been given than when potassium or sodium cyanide has been administered. However, the average time in the hydrocyanic acid cases is in part due to two animals that appear to have been unusually resistant. One of these collapsed after 24½ minutes and one after 51½ minutes. With these eliminated the average time was 3 minutes 33 seconds. Of the 23 cases, 17 (or 75 per cent) collapsed in 3 minutes or less. Following the administration of potassium cyanide there were likewise two prolonged cases, one lasting 19 minutes, and one 23½ minutes before collapse. Without these, the average time is 2 minutes 17 seconds. Of the 80 cases 80 per cent collapsed in 3 minutes or less. With sodium cyanide the average is essentially the same as for the potassium cyanide cases. Of the 18 cases, 13 (or 72 per cent) collapsed in 3 minutes or less.

Taking all facts into consideration, it is not apparent that any essential differences exist in the rate at which illness develops following the administration of the three forms of cyanide under consideration. If any one of the substances acts more slowly than the others, it is the hydrocyanic acid.

THE EFFECTIVENESS OF THE REMEDY USED

As previously stated, 7 animals that had received sodium cyanide were treated with the nitrite-thiosulphate combination. Each animal

was injected intraperitoneally with 15 c.c. of a solution containing 1 gram of sodium nitrite and 2 grams of sodium thiosulphate, the two solutions being mixed just before being injected. The quantities of sodium cyanide given these animals varied from 2.5 to 3.15 times the m.l.d. The remedy was administered in from 1½ minutes to 4 minutes after the cyanide. The results are shown in table 4.

TABLE 4.—SHOWING THE EFFECTS OF THE NITRITE-THIOSULPHATE COMBINATION ADMINISTERED INTRAPERITONEALLY AS A REMEDY FOR SHEEP POISONED BY SODIUM CYANIDE

Date 1935	Sheep		Dose m.l.d.	Time in minutes from giving drench of NaCN to			Result
	No.	Weight kg.		Symptoms	Collapse	Giving remedy	
Jan. 18	1482	38.55	2.5	0.75	3.25	3.75	Recovery
18	1480	47.62	2.75	1.00	1.75	1.50	Death
18	1481	42.63	2.75	1.5	2.25	2.25	Death
18	1457	34.92	3.00	1.0	3.72	4.00	Recovery
18	1477	41.72	3.00	0.5	1.75	3.25	Death
18	1478	38.55	3.00	1.0	2.5	3.00	Recovery
16	1473	40.82	3.15	0.75	1.00	2.00	Recovery

Four of the 7 cases, including 3 of the 4 given 3 m.l.d. of sodium cyanide recovered. As shown by the few cases the nitrite-thiosulphate combination is as effective against sodium cyanide as against potassium cyanide[3] poisoning, but apparently somewhat less effective than against hydrocyanic acid.[4]

SUMMARY

When given to sheep as a drench in water solution, 4.15 mg. of sodium cyanide per kg. of animal weight produced symptoms of poisoning and 5.22 mg. or more killed, and these quantities are considered to be the approximate minimum toxic and minimum lethal doses, respectively.

Basing the doses on the CN content, sodium cyanide is somewhat less toxic than potassium cyanide or hydrocyanic acid.

Following the administration of sodium cyanide the average time to the appearance of symptoms is approximately 1 minute, to collapse 3 minutes, and to death 34½ minutes. Taking into account the probability of experimental error, these respective periods are about the same as for poisoning by potassium cyanide or by hydrocyanic acid.[4]

The nitrite-thiosulphate combination was effective in 57 per cent of the cases in which it was tried.

[3] This JOURNAL 24: 528–532. 1934.
[4] This JOURNAL 25: 272–276. 1935.

PALEONTOLOGY.—*Notes on the genus* Breviarca.[1] LLOYD WILLIAM STEPHENSON, U. S. Geological Survey.

The name *Breviarca* was introduced by Conrad[2] in 1872 as a subgenus of *Trigonarca* Conrad (not *Trigonoarca*). He did not specify a genotype, but named two examples, *Trigonarca perovalis* Conrad, from the Snow Hill member of the Black Creek formation of North Carolina, and *Trigonarca saffordi* Gabb. The former species was later erroneously described by Conrad[3] under the name *Trigonarca* (*Breviarca*) *carolinensis*. The type of the true *Trigonarca saffordi* (Gabb)[4] came from the Midway group (Eocene), Hardeman County, Tenn., and is now known to be a *Cucullaea;*[5] Gabb originally assigned it to *Arca*.

Meek[6] in 1876, treated *Breviarca* as a subgenus of *Trigonarca* and named *Trigonarca perovalis* Conrad as an example. The first author who definitely designated a genotype for *Breviarca* was Stewart[7] who in 1930 selected *Trigonarca saffordi* (Gabb) Conrad, the second example cited by Conrad. Emphasis is to be placed on the fact that Stewart's selection pertained to the specimen figured by Conrad (his pl. 2, fig. 3), which, as shown below, was a specimen identified as *saffordi* from the Woodbury clay of the Matawan group, Haddonfield, New Jersey, and was not from Hardeman County, Tenn.

Whitfield,[8] in 1885 treated *Breviarca* as a genus and accepted the specific name *saffordi* for the New Jersey material. He says, "The specimen which I have figured on plate 12, figs. 11 and 12, appears to be the same with that used by Mr. Conrad for generic figures in 1872, and I have made the figures as accurately as it is possible to measure the specimen."

The specimen to which Whitfield refers is a right valve preserved in the Academy of Natural Sciences of Philadelphia, and is accompanied in the same tray by 13 other smaller shells, 9 left valves and 4 right valves; the lot is from Haddonfield and bears the number 13141. This lot has been kindly lent to me by the authorities of the Academy. I

[1] Published by permission of the director, U. S. Geological Survey, Washington, D. C. Received June 10, 1935.

[2] CONRAD, T. A. Acad. Nat. Sci. Philadelphia, Proc. **24**: 55, pl. 2, figs. 3, 4. 1872.

[3] CONRAD, T. A. Rept. Geol. Survey North Carolina. **1**: App. A: 3, pl. 1, fig. 4. 1875. See also STEPHENSON, L. W., North Carolina Geol. and Econ. Survey. **5**: 110. 1923.

[4] GABB, WM. M. Acad. Nat. Sci. Philadelphia, Proc., 2d ser., **4**: 397, pl. 68, fig. 38 (not fig. 37). 1860.

[5] HARRIS, G. D. Bull. Amer. Paleontology. **1**: no. 4: 51–53, pl. 3, fig. 11; pl. 4, figs. 1, 2. 1896.

[6] MEEK, F. B. Rept. U. S. Geol. Survey Terr. **9**: 90–91. 1876.

[7] STEWART, RALPH. Acad. Nat. Sci. Philadelphia Special Publication **3**: 86. 1930.

[8] WHITFIELD, R. P. U. S. Geol. Survey Mon. **9**: 87–88, pl. 12, figs. 11, 12. 1885.

have carefully compared the large right valve with the figures given by both Conrad and Whitfield, and am convinced it is the specimen figured by them; it is marked with a green and a red diamond. Further evidence is afforded by two card labels in Conrad's handwriting, to which specimens had been glued, one bearing the name *Trigonarca saffordi* Gabb, and the other *Trigonarca* (*Arca*) *saffordi* Gabb.

It is clear from the foregoing facts that the Haddonfield specimen, which must be accepted as the genotype of *Breviarca*, was incorrectly referred to Gabb's species *saffordi* and that it is in need of a new name. I therefore propose the name *Breviarca haddonfieldensis*, and designate as holotype the large right valve from Haddonfield, figured by Conrad in Academy of Natural Science Philadelphia Proceedings, vol. 24, p. 55, pl. 2, fig. 3, 1872, and by Whitfield in United States Geological Survey Monograph, vol. 9, p. 87, pl. 12, figs. 11, 12, 1885. The specimen is adequately described by Whitfield. Twelve of the 13 shells accompanying the holotype (9 left and 3 right valves) belong to the same species as the figured specimen. The thirteenth shell, a right valve, differs from the others in form, and resembles *Breviarca umbonata* (Conrad), from the Snow Hill member of the Black Creek formation of North Carolina; this shell has been placed in a separate vial.

It follows that the genotype of *Breviarca* is *Trigonarca saffordi* (Gabb) Conrad (=*Breviarca haddonfieldensis* Stephenson), and not *Cucullaea saffordi* (Gabb).

In 1923 I referred Conrad's species *Trigonarca* (*Breviarca*) *perovalis* and five other associated species, to the genus *Striarca*, which is based on *Arca centenaria* Say, a species from the Miocene of Maryland. The principal common character which was thought to indicate this congeneric relationship, was the transversely striated triangular ligamental area. After further consideration I am now of the opinion that, although the Miocene and Cretaceous species do possess this feature in common, and are related, there are sufficient differences in form and ornamentation to warrant retaining Conrad's *Breviarca* for the Cretaceous species.

BOTANY.—*The status of* Pellaea compacta (*Davenp.*) *Maxon, and a probationary method in systematic botany.*[1] JOSEPH EWAN, University of California. (Communicated by W. L. JEPSON.)

There occurs at elevations of 6500 to 8800 feet in the mountains of southern California an endemic fern whose systematic status has vari-

[1] Received April 2, 1935.

ously shifted. *Pellaea compacta* (Davenp.) Maxon was first published by J. G. Lemmon as var. *californica* of *Pellaea Wrightiana* Hook. in 1882.[2] The following year George E. Davenport published *Pellaea Wrightiana* var. *compacta*,[3] based on material from the same general locality (San Bernardino Mts.) as that studied by Lemmon. Maxon clarified the *Pellaea* confusion in the Southwest by delimiting what had long been taken *sensu latissima* as *Pellaea Wrightiana*, of which he had summarily said in 1901 "extremely variable,"[4] and by proposing in 1917 *Pellaea compacta*[5] as the name, now in full specific rank, for the endemic high-montane fern of southern California. Munz and Johnston considered the characters for this species and its indubitable relative, *Pellaea mucronata* (D.C. Eaton) D.C. Eaton, as not varying together, and therefore in 1922 combined the oldest varietal name with *Pellaea mucronata* to constitute var. *californica* (Lemmon) M. & J.[6] Subsequently Maxon[7] and Jepson[8] have maintained this fern in species status.

My first introduction to *Pellaea compacta* in the field was very possibly in the locality at which W. G. Wright first collected it, though I was unaware of the fact at the time, on the slopes of Mt. San Bernardino at 7500 feet elevation in the range of that name (*Ewan*, July 22, 1928). Although Maxon[9] gives a more general locality, from the text of Davenport's varietal description I believe that Wright must have collected it there. Moreover, the Wright collection seen in the Eaton Herbarium by Maxon and considered by him as being collected on Mt. San Bernardino at "7000 feet" is very probably from the same station, if not collected at the same time as the specimen Davenport had before him when he described his var. *compacta*. My conclusions regarding Wright's collections are reached by studies made particularly at the Los Angeles Museum, where they are well represented. I found here collections of the same species differing but slightly in the wording of their sketchy labels, which upon a close examination could be unquestionably considered as of the same collection. *Pellaea compacta* grows on the higher slopes of Mt. San Bernardino along the old trail, now little used, that leads from Mill Creek (precisely from Forest Home, a resort at 5300 feet in that

[2] LEMMON, J. G. *Ferns of the Pacific Coast* (San Francisco, 1882). p. 10.
[3] DAVENPORT, GEO. E. *Cat. Davenport Herbarium Suppl.* 46. 1883 (fide MAXON, Proc. Biol. Soc. Wash. 30: 183. 1917, not seen).
[4] MAXON, W. R. *List of ferns and fern allies of North America north of Mexico*, etc. Proc. U. S. Nat. Mus. 23: 634. 1901.
[5] MAXON, W. R. *Notes on western species of* Pellaea. Proc. Biol. Soc. Wash. 30: 183. 1917.
[6] MUNZ, P. A. & JOHNSTON, I. M. *Distribution of Southern California Pteridophytes*. Amer. Fern Jour. 12: 106. 1922.
[7] MAXON in ABRAMS, LEROY. *Illus. Flora Pacific States* 1: 31. 1923.
[8] JEPSON, W. L. *Man. Fl. Pl. Calif.* p. 33. 1923.
[9] MAXON. Proc. Biol. Soc. Wash. 30: 183. 1917.

Fig. 1.—a. *Pellaea compacta* (Davenp.) Maxon. Typical plants; Islip Trail, near Islip-Hawkins Divide, 7,500 ft., San Gabriel Mts., *Fosberg & Ewan* 4891. b. *P. compacta*. Atypical (ecologic) plants from lower margin of its range; Big Cienaga above Crystal Lake, 6,500 ft., San Gabriel Mts. *Ewan* 2704. c. *P. mucronata* (D. C. Eaton) D. C. Eaton. Typical plant; Cajon Pass, 4,000 ft., San Bernardino Co., *Ewan* 5564.

watershed) to Dobbs Cabin[10] and eventually to the summit. It may be found poking out from beneath large boulders on the gravelly talus slopes thinly populated by very fine veteran Jeffrey Pines. It persists when such slopes are transformed into unsightly "burns" and the insolation much increased.

Though passing through a considerable size range (blade at maturity falling about two averages: 3–5 or 8–12 cm. long), the plants in their optimum habitats show a group of constant morphological characters and match other collections from similar montane elevations through the region occupied, in the compactness and configuration of their blades. I have observed and collected this fern whenever botanizing in the higher mountains, continually marvelling at its distinctness in the field and at its "intermediate" states. I consider "typical" *Pellaea compacta* to be represented by such a collection as *Lemmon*, May 30, 1876 (UC), likely a topotype (postulating Mt. San Bernardino as the type locality), and *Pellaea mucronata* by such collections as *Geo. B. Grant* 920 from "Sierra Madre Mountains" (i.e. San Gabriel Mountains "behind" Pasadena and San Gabriel Valley) and *Braunton* 750 from Eaton Canyon, San Gabriel Mountains. *Pellaea mucronata* is also well illustrated by a photograph in Christ's work on the geography of Polypodiaceae.[11] To my knowledge there has never heretofore been published a photograph of *Pellaea compacta*.

I concur with Munz and Johnston that between *Pellaea compacta* and *Pellaea mucronata* "the most striking difference is in the arrangement of the pinnules,"[12] giving a wholly different aspect to these ferns in their typical states, as illustrated by *figs. 1 a* and *c*. After the examination of more than two hundred sheets of the two species involved I present Table 1 of *differentiae:*

The habitat and altitudinal distribution of these Pellaeas likewise differ, for whereas *mucronata* favors the semi-shade beneath sclerophyllous shrubs of the foothill chaparral belt, especially the widespread *Adenostoma fasciculatum* association, *compacta* is found in the boulder crevices of open ridges and slopes, often along exposed "divides." And whereas *mucronata* uncommonly ascends to the lower portions of the Transition Zone, where it often occupies less xerophytic situations, *compacta* is normally an inhabitant of the upper Transition Zone. Maxon quotes Parish[13] as to the existence of a "geographical hiatus between the two species in which no *Pellaea* occurs," but I have seen collections of the two species altitudinally only 1200 feet apart and it seems unlikely that the two ferns do not meet. It is true that the two Pellaeas do not commonly merge and that there is a "fairly distinct geographic range."[14] It is from such meeting-grounds as San Antonio Can-

[10] Dobbs Camp, on U. S. Geol. Survey San Gorgonio Quadrangle, ed. 1902, reprint 1927. Precisely a delapidated cabin at a cienaga on Falls Creek.
[11] CHRIST, H. *Die Geographie der Farne*, p. 158, fig. 72, 1910.
[12] Amer. Fern. Jour. 12: 107. 1922.
[13] Amer. Fern Jour. 8: 90. 1918.
[14] Amer. Fern Jour. 12: 107. 1922.

TABLE 1.—DISTINGUISHING CHARACTERS OF PELLAEA MUCRONATA AND P. COMPACTA

	P. mucronata	*P. compacta*
Attitude of pinnae "in nature"	Ranked in 2 planes to form a trough with a basal right angle	Curving toward each other to form an imperfect cylinder
Attitude of pinnae on herbarium sheet	Usually obliquely ascending (whereas widely spreading in the field)	Secundly superimposed as any cylinder would appear if flattened (see *fig. 1, a*)
Length of stipe	Stipe as long as the blade or less	Stipe always longer than the blade (to twice as long)
Spacing of pinnae	Pinnae distant their width	Pinnae all contiguous to pairs above and below
Division of pinnae	Pinnae always partly bipinnate (i.e. pinna divisions near rachis trifid)	Pinnae strictly pinnate (i.e., pinna divisions always simple)
Pinnule* orientation	Pinnule when unrolled (in nature by drenching rains, in laboratory by boiling) never overlapping adjacent pinnules	Pinnule when unrolled (never under *normal* conditions in nature, in laboratory by boiling) closely overlapping each adjacent pinnule
Pinnule gross morphology	Pinnule, though strongly revolute, not strictly conduplicate but more nearly terete and not at all falcate	"Fertile pinnules . . . broadly revolute, often conduplicate and falcate with age." A false intruded suture and characteristic shape give an *Astragalus*-pod aspect to the pinnule (under binocular)
Duration of fronds	Pinnules deciduous, to leave naked spinose pinna rachises	Pinnules persistent; last year's weathered fronds (stone gray color) intact among fronds (gray green) of the season
Dry season condition	Pinna segments appear as pendent bullate sacs from filiform wiry rachises; thus wholly unlike divaricate aspect of wet season	Pinna segments appear as equally ranked members on either side of rachises; unaltered in position throughout the year

* Pinnule here taken as the ultimate segment of any fern pinna.

yon, San Gabriel Mountains, the place of the above observation, that the troublesome outlying variants arise.

The intermediate (better simply "atypical") states of these two species are due, I believe from field observation, to ecologic (soil or climate or both) factors which may affect either species, occurring chiefly along the margins of their vertical ranges, as when *mucronata* interfingers upwards into the lower Transition Zone. Plants of *Pellaea mucronata* near its upper altitudinal limits may have much reduced pinnules, and these abundant and crowded

—not at all like the common foothill fern in aspect—which comes close to the outlying forms of *compacta* as that species reaches its lower limits. *Fosberg* 8497, San Antonio Canyon, 4500 feet, represents this phase.

On the other hand when *Pellaea compacta* grows in partial shade under pines it may assume the habit of *P. mucronata* in bearing the pinnae divaricately, in the manner of the Arizonan *Pellaea Wrightiana*. This condition is illustrated by *Johnston* 1593, San Antonio Canyon, San Gabriel Mountains, at 5750 feet—about the lower altitudinal limit for *compacta!*—and a likely zone of flux. Here the aspect of *compacta* is quite unlike plants at higher altitudes in the same range. Furthermore, when this species grows in deep north-facing crevices of boulders the pinnae may assume more widely atypical asplenioid forms (*fig. 1, b*) with a few plane rounded pinnules. Growing at the same station, however, at Big Cienaga above Crystal Lake, San Gabriel Mountains (at 6500 feet—here the zone of flux because of the ascent of the Sonoran elements immediately below to raise the whole zonation), are plants of *compacta* (*Ewan* 2703) with divaricate pinnae and of open habit, nearly plane, and only slightly glaucous, whereas typical *compacta* is often distinctly glaucous. Still other plants from this station (*Ewan* 2702), growing in the full sun, match the Lemmon collection above cited from the San Bernardino Mountains in all characters. It is such a typical collection (*Fosberg & Ewan* 4891—though not the Big Cienaga collection referred to above) that is illustrated by *fig. 1, a*. Careful search will then disclose what might be taken as negative evidence for concluding that *Pellaea compacta* is a valid species, but there appears to me to be yet another justified conclusion and disposition.

The systematic relationship in these ferns introduces a principle in the treatment of "unstable species" that, as a working idea, merits consideration. Both *Pellaea mucronata*, conceivably the parent species, and *Pellaea compacta*, the derived species resulting from isolation, in part, and its multiplex resulting factors, are very susceptible to an abnormal environment, with consequent morphological changes away from those characters exhibited by plants of typical habitats. Especially does this reaction occur when the two species approach their altitudinal limits. Irrespective of such uncertain forms as may be found, not at once referable to either species but always peripheral in distribution and numerically few among the species as a whole, a sound working basis is to maintain the limits, when well-defined, as distinct species. Perhaps a parent species and such a limital one may represent a confluent unit, were all the intercalary states known. Nevertheless the recognition of such limital species awaits the day, perhaps decades distant, when a comprehensive knowledge from several correlated fields of study will relate the data presented by new collections in the then better understood mosaic of life forms among plants. The chief disadvantage with the practice of relating minor or questionable limital forms to another long-known species on present incomplete evidence is the fact that such a practice

hides away these plants from the critical observation which might easily be given them were they maintained by botanists on "trial grounds." A recommended practice for the consideration of such uncertain (published) forms in manuals and floras is that in favor among many botanists in giving a characterization (preferably quite full, if not verbatim, from the original description) of such forms, without keying them, as a subhead near the most closely related keyed species.

Therefore, when a plant exhibits a clear set of morphological characters under optimum growing conditions for that species and these characters recur among plants found in similar floristic areas, I favor the recognition of such plants (the "extremes" of some botanists) as species. Many such species may be found commonly to terminate a phylogenetic line, recently budding from the parent species, and therefore will be areally limited. The dubious forms that occur between such species would be then considered taxonomically as individuals, at the same time pointing out their avowed differences and affinities and relating them when practicable to the species which they most nearly approach in the sum total of their characters. This treatment, as species, of what have often been considered as "extremes" necessitates the clear definition of such a plant group, repeating an appreciable number of times the characters present over several floristically related stations.[15] Allowing for local or individual genetic variation the majority of the "intermediates" will be found, I believe, to represent plants in active evolution on the margins of their normal ranges, immigrants into new territory.

O. F. Cook's simile in elucidating the species problem is, among the verbiage extant on that topic, a happy one. "The categories of the biologist are artificial like those of the geographer, but not more so. Geographers do not agree in the grouping of the archipelagoes of the Pacific Ocean, but this is not considered a reason for denying that islands exist or that some islands are close together and others far apart. Species are biological islands, in a sea of non-existence."[16] Awaiting the results of studies by the experimental grower, the geneticist, ecologist, and student of nutrition, the systematic botanist holds a probationary attitude toward the lesser known plant forms in an attempt to differentiate between specific units and those marginal states which approach the better known species in one or several characters, meanwhile being in accord with the view that the ultimate "only way to solve taxonomical difficulties with polymorphic species goes along lines of experimental research."[17]

[15] For "narrow endemics" 3 or 4 stations would suffice, if these were of the same floristic subarea populated by identical or closely related species at the separate stations.

[16] Cook, O. F. *Existence of species.* Jour. Hered. 5: 158. 1914.

[17] Goddijn, W. A. *On the species conception in relation to taxonomy and genetics.* Blumea 1: 81. 1934.

SUMMARY

Pellaea compacta (Davenp.) Maxon is believed to have been first collected on the slopes of Mt. San Bernardino, where it grows in fair abundance, though not definitely so stated in Davenport's original description of the fern.

Pellaea compacta, confined to the higher mountains of southern California, morphologically well-defined in its typical state but undergoing wide variation under abnormal environments, is considered specifically distinct from the geographically widespread *Pellaea mucronata*.

The so-called "intermediates" of the two species are found to occur invariably along the margins of their vertical ranges, being absent from *within* the range of typical plants of either species. These outlying forms are generally atypical in only one or two characters which may be understood from field observation to be of edaphic or climatic origin.

Well-defined limital forms (what have often been tagged "extremes") of generally accepted species, sharing with the plants of several floristically related localities definite morphological characters, are recommended to be treated as species.

Atypical forms may be best considered as "near" or "towards" either species according to the sum total of their characters, with a clear statement of their aberrant morphological nature.

BOTANY.—*New species of* Bomarea *from the Andes.*[1]

E. P. KILLIP, U. S. National Museum.

Bomarea, a genus of Amaryllidaceae, contains some of the most showy plants of the South American mountains. The brilliant flowers, usually red and yellow, are often massed in clusters of 50 or more, and present a striking appearance against the dark green foliage of the forest. Though most of the species are high-climbing vines, some inhabit the high mountain plateaus, and these generally are low erect plants, with stiff narrow leaves.

As a member of expeditions to Colombia and Peru I have made a special study of *Bomarea*, and am preparing a revision of the genus. Since this can not be published at present, and the names of several new species are used in a forthcoming article in The National Horticultural Magazine, I am describing herewith eleven as new, most of these based upon material in the herbaria of the Royal Botanic Gardens, Kew, the Muséum National d'Histoire Naturelle, Paris, and the Botanisches Museum, Berlin. To the directors of these institutions I wish to express my appreciation of their many courtesies. Photo-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received June 4, 1935.

graphs, and in some cases fragments of the types, are deposited in the U. S. National Herbarium.

The most comprehensive monographs of Amaryllidaceae are those of Herbert,[2] Kunth,[3] and Baker.[4] In treating *Bomarea* Baker recognized as subgenera two small groups of species, which both Herbert and Kunth had placed in separate genera, these subgenera being designated by Baker as *Wichaurea* and *Sphaerine*. In classifying the true Bomareas Baker followed his predecessors in recognizing four main groups, as follows:

Umbel rays simple.

Petals and sepals subequal (*Multiflorae*).

Petals much longer than the sepals (*Caldasianae*).

Umbel rays forked.

Petals and sepals subequal (*Edules*).

Petals much longer than the sepals (*Vitellinae*).

I have given names to these groups as above, in order to refer to them more readily. The arrangement is not wholly satisfactory, and perhaps does not express the actual relationships of the species, but until more herbarium material, expecially more fruiting material, is available, it will suffice.

Bomarea (*Wichaurea*) **campanuliflora** Killip, sp. nov.

Caulis strictus (?), parte suprema recurvata, glaber; folia linearia, revoluta, rigida, subtus rufo-pilosula; radii 4, glabri, 1–2-furcati; ovarium ±superius, glabrum; sepala late ovata, rubra; petala oblanceolato-unguiculata, quam sepala longiora, rubra, apice viridi.

Stem apparently erect, recurved toward apex, about 3 mm. in diameter, leafy except toward base, glabrous; leaves linear, 3 to 9 cm. long, decreasing toward apex, 3 to 6 mm. wide (the upper the broader), crowded, strongly revolute, rigid, sessile, rufo-pilosulous beneath; bracts similar to the leaves, slightly involute; umbel rays 4, about 4.5 cm. long, glabrous, once or twice forked, bracteolate, the lowest bractlets up to 2.5 cm. long; ovary broadly turbinate-campanulate, glabrous, partly superior; sepals broadly ovate, 2 to 2.5 cm. long, 1 to 1.5 cm. wide, acuminate, glabrous, red; petals oblanceolate-unguiculate, 2.5 to 3 cm. long, the blade longer than the claw, 1 to 1.3 cm. wide, acute, red, green-tipped; stamens subequal to the petals, the anthers oblong, about 3.5 mm. long; styles exserted, the stigma shallowly trifid.

Type in the herbarium of the Botanisches Museum, Berlin, collected at Quebrada de Toipata (?), Department of Puno, Peru, August, 1864, by A. Raimondi (no. 10229).

The general appearance of the inflorescence suggests *B. grandis*, but because of the proportionately broad sepals and the strongly involute leaves it is evidently a distinct species.

[2] HERBERT, W. Amaryllidaceae. 1837.
[3] KUNTH, C. S. Enum. Pl. 5: 467–850. 1847.
[4] BAKER, J. G. Handbook of the Amaryllideae. 1888.

Bomarea (*Wichaurea*) **zosteraefolia** Killip, sp. nov.

Ubique glaberrima; caulis strictus, rigidus, ad apicem recurvatus, foliosissimus; folia linearia, subrevoluta, membranacea; radii ca. 6, prope medium furcati; ovarium turbinatum; segmenta perianthii subaequalia, sepalis lineari-oblongis, subacutis, petalis oblongo-spathulatis, flavescentibus (?), purpureo-maculatis.

Plant erect, rigid, 30 or more cm. high, glabrous throughout; stem subterete, 2.5 to 4 mm. in diameter, recurved toward apex, densely leafy, the leaves reduced or probably wanting toward base; leaves linear, 4 to 12 cm. long, 2 to 3 mm. wide (diminishing from middle of stem to apex), acute, sessile, slightly revolute, membranous, green on both surfaces, divaricate; bracts similar to the leaves; umbel rays about 6, 2.5 to 3 cm. long, slender, forked near middle, the bractlets similar to the leaves, 1.5 to 2 cm. long; ovary turbinate, sulcate; sepals linear-oblong, about 2.5 cm. long and 6 mm. wide, subacute, red, green-tipped; petals oblong-spatulate, subequal to the sepals, yellowish(?), green-tinged and purple-maculate at apex; stamens subequal to the perianth, the anthers oblong, about 2.5 mm. long; style slightly exserted, trifid.

Type in the herbarium of the Muséum National d'Histoire Naturelle, Paris, collected in the Department of Ancachs, Peru, by Martinet (no. 742).

The longer spreading leaves, which are of a much thinner texture, scarcely revolute, and glabrous beneath, and the diffuse inflorescence are characters by which this may be distinquished from *B. dulcis*, a related species.

Bomarea uniflora (Mathews) Killip

Alstroemeria uniflora Mathews; Herb. Amaryll. 104. 1837, as synonym.
Wichaurea dulcis uniflora M. Roemer, Fam. Nat. Syn. **4**: 278. 1847.

Bomarea (*Sphaerine*) **incana** Killip, sp. nov.

Caulis strictus, teres, tener, glaber; folia pauca, ovato-oblonga, membranacea, subtus pilis albidis vel brunnescentibus dense hirsuto-tomentosa; radii 1 vel 2, ad medium furcati vel subfurcati, bracteolis foliis similibus; ovarium auguste obconicum, rufo-tomentellum; segmenta perianthii aequalia, sepalis oblongis, petalis oblanceolato-spathulatis, flavis, apice viridi, purpureo-punctatis.

Stem erect, 50 to 60 cm. high, slender, terete, glabrous, leafless in lower half, few-leaved in upper half; leaves sessile or subsessile, ovate-oblong, 4–6 cm. long, 1.2 to 2.3 cm. wide, acute at apex, rounded at base, membranous, glabrous above, densely hirsute-tomentose beneath with white or light brown hairs, the hairs chiefly borne on the side of the veins, divaricate but closely appressed to the blade; bracts 2, similar and equal to the leaves; umbel 1 or 2-rayed, the rays 5 to 12 cm. long, forked near middle (or one fork scarcely developed), bracteolate at fork, the bractlets similar to the leaves, 1.5 to 3 cm. long; ovary narrowly obconic, densely rufo-tomentellous; perianth segments equal, 2 to 2.3 cm. long; sepals oblong, 6 to 9 mm. wide, red and puberulous without, pale and glabrous within; petals oblanceolate-spatulate, the blade 6 to 7 mm. wide, yellow, green-tinged apically and purple-spotted; stamens subequal to perianth; stigma trifid.

Type in the herbarium of the Jardín Botánico, Madrid, collected at the Alto del Cóndor, between Ibagué and El Nevado del Tolima, Department of Tolima, Colombia, altitude 3,500 meters (Central Cordillera), May 17,

1932, by J. Cuatrecasas (no. 2224). Represented also by *Goudot* 4 and *Dawe* 807, from the same general region.

This is nearest *B. holtonii*, also a Colombian species, which has 7 or 8 primary rays, a quadrangular stem, and sparingly pilosulous leaves.

Bomarea (*Eubomarea* § *Caldasianae*) **vegasana** Killip, sp. nov.

Caulis volubilis, angulatus, rufo-tomentulosus; folia lanceolata, subcoriacea, subtus minute puberula; radii ca. 35, simplices, ebracteolati, cum ovario conico viscoso-tomentosi; sepala lineari-oblonga; petala cuneato-unguiculata, sepalis longiora, lutea.

Herbaceous vine; stem rather stout, 4 to 6 mm. wide, angular, densely rufo-tomentulous; petioles 6 to 8 mm. long, winged; leaves lanceolate, 8 to 12 cm. long, 2 to 2.5 cm. wide, acuminate at apex, abruptly narrowed at base, subcoriaceous, glabrous above, minutely puberulent beneath; bracts of 2 forms, the outer oblong-lanceolate, 3 to 5 cm. long, 8 to 10 mm. wide, reflexed, the inner linear, 1 to 1.5 cm. long, 3 mm. wide, suberect; umbel simple, about 35-rayed, the rays 4 to 5 cm. long, ebracteolate, viscous-tomentose; sepals linear-oblong, about 3 cm. long, 6 mm. wide, red, puberulent without; petals cuneate-unguiculate, about 4 cm. long, the blade subequal to the claw, yellow, not spotted; stamens 3 to 3.5 cm. long, unequal, the anthers ovate-oblong, 6 to 7 mm. long.

Type in the U. S. National Herbarium, no. 1,351,609, collected in mountains east of Las Vegas, Department of Santander, Colombia, altitude 3,300 to 3,400 meters (Eastern Cordillera), December 21, 1926, by E. P. Killip and A. C. Smith (no. 15784). Represented also by *Killip & Smith* 15587, from the same locality.

This closely resembles *B. andreana*, but the petals are definitely unspotted and the leaves, which are of thicker texture, are minutely puberulent beneath.

Bomarea (*Eubomarea* § *Edules*) **subsessilis** Killip, sp. nov.

Caulis substrictus et subflexuosus, tenerrimus, glaber; folia oblanceolata vel elliptica, ad basin attenuata, subsessilia, subtus breviter crispato-pilosa; bracteae 2; radii 2–4, tenerrimi, glabri, 1–2-furcati, bracteolis parvis; ovarium late turbinatum; segmenta perianthii subaequalia, apice viridi, sepalis oblongo-spathulatis roseis, petalis spathulatis-unguiculatis, flavidulis.

Stem 35 to 50 cm. long, suberect or at least very slightly voluble, subflexuose, angulate, slender, glabrous; leaves oblanceolate or elliptic, 2.5 to 5.5 cm. long, 0.7 to 1.8 cm. wide, acute at apex, tapering to base without a well-defined petiole, resupinate, divaricate or somewhat ascending, membranous, glabrous above, short-crispate-pilose beneath; bracts 2, ovate-oblong, 7 to 13 mm. long, 3 to 5 mm. wide; umbel 2 to 4-rayed, the rays slender, 3.5 to 4.5 cm. long, glabrous, once or twice forked, bearing at the forks an ovate-oblong or linear-oblong, reddish bractlet 7 to 10 mm. long; ovary broadly turbinate, 6 to 8 mm. long, up to 6.5 mm. in diameter at apex, about one-fifth superior, longitudinally sulcate, glabrous, black; sepals oblong-spatulate, 1.2 to 1.6 cm. long, 5 to 7 mm. wide, obtuse, reddish pink, green at apex; petals spatulate-unguiculate, subequal to sepals in length and breadth, pale yellow, green-tinged; stamens shorter than the perianth, unequal, the anthers orbicular-oblong, about 1.5 mm. long; pistil subequal to stamens, the stigma trifid.

Type in the herbarium of the Botanisches Museum, Berlin, collected near Cochabamba, Department of Cochabamba, Bolivia, 3,400 meters altitude, February 27, 1928, by C. Troll (no. 1630). Represented also by *Bang* 2039, from the same locality.

This is one of several species that are clearly distinct in themselves but which, because of our imperfect knowledge of the lines of demarcation of the subgenera, are difficult to assign systematically. The suberect habit of the plant, the absence of a definite petiole, and the partly superior ovary suggest the subgenus *Wichaurea*. In other respects it seems more closely allied with the small-flowered species of *Eubomarea* § *Edules*.

Bomarea (*Eubomarea* § *Edules*) **campylophylla** Killip, sp. nov.

Caulis volubilis, teres, glaber; folia lineari-lanceolata, subfalcata, conspicue nervosa, glabra; bracteae foliis similes, falcatae; radii 5 vel 6, subglabri, supra furcati, biflori, 1–2-bracteolati; ovarium cylindrico-turbinatum; segmenta perianthii subaequalia, sepalis oblongis, petalis spathulatis, quam sepalis augustioribus, luteis, purpureo-maculatis, apice viridi.

Herbaceous vine; stem terete, 2 to 3 mm. in diameter, glabrous; petioles up to 6 mm. long, crispate-margined; leaves linear-lanceolate, 6 to 12 cm. long, 1 to 1.5 cm. wide, subfalcate, acuminate at apex, rounded at base, strongly and closely nerved, glabrous, concolorous; bracts similar to the leaves, 7 to 10 cm. long, 5 to 8 mm. wide, falcate; umbel 5 or 6-rayed, the rays 10 to 15 cm. long, divaricate or arcuate-ascending, rufo-puberulent and viscid at apex, otherwise glabrous, forked near apex, 2-flowered, bracteolate at fork and sometimes just below fork, the lower bractlets similar to the bracts, 4 to 5 cm. long; ovary cylindric-turbinate, densely rufo-tomentose; perianth segments subequal, about 1.5 cm. long, the sepals oblong, 7 to 8 mm. wide, red and rufo-puberulent without, yellow within, green at apex, the petals spatulate, slightly narrower than the sepals, yellow, purple-maculate, green at apex; stamens shorter than the perianth, the anthers ovate-oblong, about 2.5 mm. long; style trifid.

Type in the U. S. National Herbarium, no. 1,192,850, collected at Villcabamba, Department of Huánuco, Peru, altitude about 1,800 meters, July 17 to 26, 1923, by J. F. Macbride (no. 4961). Duplicate at the Field Museum.

This is allied to *B. salsilla*, *B. subsessilis*, and *B. nematocaulon*, species of *Eubomarea* § *Edules* with very small flowers, the perianth being not more than 1.5 cm. long. There are many points of difference between these three species and *B. campylophylla*.

Bomarea pennellii Killip

Bomarea longipes Kränzl. Bot. Jahrb. Engler **40**: 234. 1908, not Baker, 1882.

In assigning a specific name to this Colombian plant Kränzlin overlooked the earlier use of *longipes* for a wholly different plant from Ecuador. It is appropriate that the species be named for Dr. F. W. Pennell, whose extensive explorations in Colombia have done much to make known the plant life of that country.

Bomarea (*Eubomarea* § *Edules*) **trichophylla** Killip, sp. nov.

Caulis volubilis, glaber; folia ovato-lanceolata, subtus in nervis dense pilosa; radii 4–7, glabri, supra medium 2–3-furcati, bracteolis oblongo-lanceolatis vel lineari-lanceolatis; ovarium late turbinatum, glabrum; segmenta perianthii aequalia, apice viridi, sepalis obovato-oblongis, extra roseis, intus flavidulis, petalis oblongo-spathulatis, luteis; capsula turbinata, aurantiaca.

Herbaceous vine; stem rather slender, 2 to 3 mm. thick, sulcate, glabrous; petioles 1 to 1.5 cm. long, narrowly winged; leaves ovate-lanceolate, 7 to 11 cm. long, 2 to 3.5 cm. wide, acuminate at apex, rounded at base, membranous, glabrous above, densely pilose on nerves beneath with divaricate whitish hairs; bracts leaflike, persistent, varying in size in individual plants from 5 to 7 cm. long and 1 to 2.5 cm. wide, petiolate, pilose on nerves beneath; umbel rays 4 to 7, 15 to 25 cm. long, glabrous, twice or thrice-forked above middle, bracteolate at the forks, the lowermost bractlets oblong-lanceolate, 1 to 1.5 cm. long, 2 mm. wide; ovary broadly turbinate, glabrous; perianth segments equal, 2 to 2.5 cm. long, the sepals obovate-oblong, 1 to 1.2 cm. wide, pinkish without, yellowish or cream-color within, green-tinged at apex; petals oblong-spatulate, 8 to 11 mm. wide, yellow, green at apex, purple-dotted within; stamens equal, slightly shorter than the perianth, the anthers ovate, 4 to 5 mm. long, 2 mm. wide; fruit turbinate, about 2 cm. in diameter, orange.

Type in the U. S. National Herbarium, no. 1,574,158, collected near Vetas, Department of Santander, Colombia, altitude 3,100 to 3,250 meters (Eastern Cordillera), January 19, 1927, by E. P. Killip and A. C. Smith (no. 17881). Represented also by several other Killip and Smith collections from the departments of Santander and Norte de Santander.

This species most nearly resembles *B. moritziana*, but differs in having glabrous rays and ovaries, larger flowers, and obovate-oblong sepals.

Bomarea (*Eubomarea* § *Edules*) **perlongipes** Killip, sp. nov.

Caulis et folia desunt; bracteae late ovato-lanceolatae, subtus dense hirsutae; radii 10 (vel ad 20?), perlongi, crassi, erecti vel adscendentes, glabri, supra medium bifurcati, bracteolis ovato-lanceolatis, infimis magnis; ovarium cylindrico-turbinatum, glabrum; segmenta perianthii aequalia, sepalis obovato-oblongis, roseis, petalis oblongo-spathulatis, luteis, brunneo-maculatis.

Stem and leaves wanting; bracts broadly ovate-lanceolate or oblong-lanceolate, 7 to 11 cm. long, 2 to 5 cm. wide, abruptly acuminate at apex, subacute at base, glabrous above, densely hirsute beneath; umbel rays 10 (up to 20?), about 40 cm. long, stout, erect or ascending, glabrous, twice-branched above middle, bracteolate at forks, the bractlets ovate-lanceolate, acuminate, glabrous above, sparingly hirtellous and puberulent beneath, the lowermost 6 to 7 cm. long, 2 to 2.5 cm. wide, the upper decreasing in size; ovary cylindric-turbinate, glabrous; perianth segments equal, 4 to 5.5 cm. long, the sepals obovate-oblong, 7 to 8 mm. wide, callous-thickened at apex, rose, the petals oblong-spatulate, 1.2 to 1.5 cm. wide, yellow, brown-spotted; stamens 3 to 3.5 cm. long.

Type in the herbarium of the Muséum National d'Histoire Naturelle, Paris, collected in the Province of Ocaña, Department of Norte de Santander, Colombia, altitude about 1,525 meters, July (1846–1852), by L. Schlim (no. 718).

The specimen at hand has been cut off just at the base of the umbel, three bracts being attached. The stem and leaves may have been mounted on another sheet or perhaps not distributed to the Paris herbarium. Schlim's 455, consisting of two leaves and a short stem only, may represent this species; it was also collected in the Province of Ocaña, but at a much higher altitude. The stem is rather slender and glabrous, and the leaves are broadly ovate (16 to 17 cm. long, 7.5 to 8 cm. wide) and bear beneath an indument very similar to that of the bracts of *B. perlongipes*.

Among the large-flowered species of this group *B. perlongipes* is readily recognized by the prominent bractlets.

Bomarea (*Eubomarea* § *Vitellinae*) **schultzei** Killip, sp. nov.

Caulis volubilis, crassus, glaber; folia late lanceolata, membranacea, subtus hirsuto-tomentosa; radii ca. 20, teneri, bifurcati, bracteolis ovatis; ovarium turbinatum, rufo-tomentulosum; sepala late ovata, roseo-rubra; petala cuneato-unguiculata, sepalis multo longiora, viridia, ad basin roseo-rubra.

Herbaceous vine, up to 4 meters long; stem stout, 4 to 5 mm. wide, subangular, glabrous; petioles up to 2 cm. long, winged; leaves broadly lanceolate, 12 to 14 cm. long, 4.5 to 5 cm. wide, caudate-acuminate at apex, rounded at base, abruptly tapering to petiole, thin-membranous, glabrous above, sparingly to densely hirsute-tomentose beneath, the nerves scarcely elevated above; bracts leaflike, lanceolate, up to 8 cm. long and 2 cm. wide; umbel about 20-rayed, the rays about 25 cm. long, glabrous, pilosulous toward apex, fairly slender, twice-branched, bracteolate at the forks, the bractlets ovate, acuminate, the lowermost up to 2.5 cm. long and 1.1 cm. wide; ovary turbinate, sulcate, rufo-tomentulous; perianth segments very unequal, the sepals broadly ovate, 2.5 to 3 cm. long, 1.2 to 1.4 cm. wide, obtuse, glabrescent, bright rose-red, the petals cuneate-unguiculate, 3.2 to 3.7 cm. long, the blade 1.4 to 1.8 cm. wide, bright green, spotted with brown, the claw slightly shorter than the blade, rose-carmine; stamens unequal, 3 about 2.7 cm. long, 3 about 8 mm. longer, the anthers ovate-oblong, about 4 mm. long; pistil about 1.5 cm. long.

Type in the herbarium of the Botanisches Museum, Berlin, collected at Aguadita, Department of Cundinamarca, Colombia, altitude 1,750 meters (Eastern Cordillera), April 12, 1925, by Arnold Schultze (no. 213).

This handsome species belongs to the small section with unequal perianth segments and forked umbel rays. It is readily distinguished from *B. vitellina*, its nearest relative, by the much broader sepals, the pubescence on the under side of the leaves, and the coloring of the petals.

Bomarea (*Eubomarea* § *Vitellinae*) **hazeni** Killip, sp. nov.

Caulis volubilis, glaber; folia ovato-lanceolata, subtus in nervis pilosa; radii 5–9, cum ovario viscoso-tumentosi, 1–3-furcati, bracteolati; segmenta perianthii inaequalia, sepalis oblanceolatis, extus pubescentibus, petalis cuneato-unguiculatis, quam sepalis longioribus, non punctatis.

Herbaceous vine; stem stout, 3 to 5 mm. in diameter, subterete, glabrous, sparingly pilosulous at extremity; petioles up to 1 cm. long, narrowly winged, densely pilosulous on one side; leaves ovate-lanceolate, 6 to 11 cm. long, 2

to 4 cm. wide, caudate-acuminate at apex, rounded at base, subcoriaceous, 15 to 20-nerved (nerves elevated beneath), glabrous and lustrous above, pilose on nerves beneath; bracts lanceolate, up to 5 cm. long, reflexed; umbel 5 to 9-rayed, the rays 7 to 15 cm. long, densely viscous-tomentose, 1 to 3 times forked, bracteolate at the forks, the bractlets lanceolate, about 1 cm. long; ovary turbinate, viscous-tomentose; perianth segments unequal, the sepals oblanceolate, 1.5 to 2.5 cm. long, 7 to 9 mm. wide, pubescent and red without, yellow within, the petals cuneate-unguiculate, about 5 mm. longer than the sepals, the blade 1 to 1.5 cm. wide, truncate, deep yellow, unspotted; stamens unequal, 3 slightly longer than the other 3, the anthers oblong, about 4 to 5 mm. long; pistil slightly shorter than the stamens.

Type in the U. S. National Herbarium, no. 1,143,705, collected at Magaña, Quindío Trail, Department of Caldas, Colombia, altitude 3,400 meters (Central Cordillera), August 2, 1922, by E. P. Killip and T. E. Hazen (no. 9174).

Additional specimens examined, all from Colombia: Cundinamarca: *Triana* 525. Tolima: *Killip and Hazen* 9492, 9500; *Pennell* 2978. Caldas: *Pennell and Hazen* 10085.

The general shape of the perianth segments and their coloring suggest species of *Caldasianae*, but the rays are forked, the secondary flowers being well developed. The species is more closely related to *B. vitellina*, which has much larger flowers and glabrous leaves.

Bomarea (*Eubomarea* § *Vitellinae*) **inaequalis** Killip, sp. nov.

Caulis volubilis, crassus, glaber; folia oblongo-lanceolata, subcoriacea, subtus in nervis dense pilosa; radii ca. 8, teneri, elongati, pilosuli, bifurcati, bracteolis ovato-lanceolatis; ovarium turbinatum, viscoso-tomentosum; segmenta perianthii valde inaequalia, sepalis obovatis, glaberrimis, petalis quam sepalis longioribus, cuneato-unguiculatis, luteis, dense purpureo-punctatis.

Herbaceous vine; stem stout, about 5 mm. wide, subangular, glabrous; petioles 1 to 1.2 cm. long, narrowly winged; leaves oblong-lanceolate, 15 to 18 cm. long, 2.5 to 3 cm. wide, acuminate at apex, rounded at base, subcoriaceous, glabrous above, densely pilose on nerves beneath; bracts ovate-lanceolate, about 4 cm. long and 1.3 cm. wide, acuminate; umbel rays about 8, slender, 12 to 15 cm. long, sparingly pilosulous below, densely so above, twice branched above middle, bracteolate at forks, the bractlets ovate, the lowermost about 1 cm. long; ovary turbinate, viscous-tomentose; perianth segments very unequal, the sepals obovate, about 1.5 cm. long and 6 mm. wide, glabrous, red (?), the petals cuneate-unguiculate, 2 to 2.3 cm. long, the blade about 1 cm. wide, yellow, conspicuously spotted with purple; stamens unequal, 3 about as long as the petals, 3 shorter, the anthers oblong, about 4 mm. long.

Type in the herbarium of the Botanisches Museum, Berlin, collected at Río Frío, Department of Santander, Colombia, July 3, 1878, by W. Kalbreyer (no. 760). Duplicate at Kew.

The petals of *B. inaequalis* are very markedly longer than the sepals and the umbel rays are forked; in this small group it comes nearest *B. hazeni*, which has pubescent sepals, small ovato-lanceolate leaves, and very obscurely marked petals.

PALEOBOTANY.—*A Douglas fir cone from the Miocene of southeastern Oregon.*[1] CHESTER A. ARNOLD, University of Michigan.
(Communicated by E. C. CASE.)

Occasional reference has been made in the literature to remains of *Pseudotsuga* in the Tertiary and Quarternary deposits of western North America but the material is seldom abundant or well preserved. A recently discovered impression of a well preserved cone which shows not only the scales but also the exserted bracts is considered worthy of mention.

The cone under consideration (fig. 1) was discovered by Mr. Percy Train in 1932 while engaged in excavating plant fossils in the Trout

Fig. 1.—*Pseudotsuga taxifolioidea* sp. nov. Natural size.

Creek diatomite in the southeastern part of Harney County, Oregon. All the organic matter of the cone had disappeared, leaving only the somewhat flattened cavity, on the inner surface of which imprints of the cone scales can be seen. A fortunate break had split the specimen exactly in half so that both sides of the cavity are retained. Extending laterally from between the closely appressed cone scales are several trident-shaped bracts, characteristic of *Pseudotsuga*. One bract is nearly complete while only portions of others are clearly visible. These bracts render generic identification of the fossil positive.

Pseudotsuga taxifolioidea Arnold, sp. nov.

The cone is 2.5 cm. wide and slightly over 8 cm. long. It is long-oval, rounded at the base, slightly broadest below the middle and rather tapering above. The scales are broad and rounded apically. They are tightly appressed, characteristic of Douglas fir cones that have been water soaked. The bracts project outward for a distance of approximately 1.5 cm. beyond the cone scales and are about 0.5 cm. wide.

The similarities between this cone and the cones of Douglas fir, *Pseudotsuga taxifolia*, are close. It is too small for the cone of *P. macrocarpa*, in which the range in length, as given by Jepson (1), Sargent (2), and Sud-

[1] Received May 2, 1935.

worth (3) may be from 10 to 18 cm. Those of *P. taxifolia* may range from 4 to 11 cm. Therefore, the Trout Creek specimen is well within the size limits of the latter species although probably somewhat larger than a cone of average size. The exsertion of the bracts is also indicative of affinity with this species since this feature is often cited as a diagnostic character. The bracts of *P. macrocarpa* protrude but little. There are no points of resemblance between this specimen and *P. japonica*, the Japanese species.

Abundant seeds from the Trout Creek diatomite have been described by MacGinitie as *Pseudotsuga masoni* (4). He also assigns twigs to this species, and it is quite possible that the seeds, twigs and cones in the diatomite all belong to the same species. Identity of these detached organs might also seem more probable as *Pesudotsuga* is not a large genus and the seeds and cones of the different species are distinguishable. Whether or not this is true for the extinct types is unknown although the fossil record does not indicate that the genus was ever a large one. The reason, however, for assigning the Trout Creek specimen to a new species is because erroneous determinations of organs in the detached condition lead to confusion. MacGinitie remarks upon the close resemblance between the seeds he assigns to *P. masoni* and those of living *P. taxifolia*, a resemblance which is indeed close. But whether these seeds belonged to a plant that is really conspecific with *P. taxifolia*, as the living species is defined, is only conjectural, since the fossil record of *Pseudotsuga* is meager. Consequently it is considered advisable to describe this cone as new while at the same time keeping in mind the close resemblance to the living species as well as its intimate association with *P. masoni*. It is felt that in this way less confusion would result if later investigations were to demonstrate that during Miocene times there were other species of *Pseudotsuga* to which these organs might belong. The name *Pseudotsuga taxifolioidea* sp. nov., is therefore proposed for this cone, the specific name indicating its resemblance to the living form. The holotype is No. 17241 of the University of Michigan collection.

Among the heretofore unrecorded species associated with *Pseudotsuga taxifolioidea* in the Trout Creek diatomite the following may be noted.

Acer bendirei Lesq.
Ailanthus sp. fruit (cf. living *A. glandulosa*)
Amelanchier sp. (cf. living *A. alnifolia*)
Castanopsis sp.
Catalpa? sp. (cf. living *C. speciosa*)
Celtis cf. obliquifolia Chaney
Cladrastis sp. nov.

Cornus sp. (cf. living *C. circinata*)
Crataegus sp. (cf. living *C. pinnatifida*)
Equisetum sp. (cf. living *E. hyemale*)
Nymphaeophyllum gen. et sp. nov.
Ostrya oregoniana Chaney (fruit sac)
Peltandra sp. nov.
Polpulus balsamoides Goepp.
Populus sp. (cf. living *P. grandidentata*)

These, along with other species, will be discussed in future publications.

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ZOOLOGY.—*Contributions to Texas herpetology. III. Bullsnakes of the genera* Arizona *and* Pituophis.[1] CHARLES E. BURT, Southwestern College. (Communicated by L. STEJNEGER.)

Four species of bullsnakes of the genera *Arizona* and *Pituophis* are now known to occur in Texas, *P. melanoleucus ruthveni* being here reported from the state for the first time. Distinguishing characters of the species are presented in the following key.

1. Keels present on some or all of the dorsal scales..... 2
   Dorsal scales smooth.
   Arizona elegans elegans (Kennicott).
2. Normally with not more than one upper labial (4 or 5) bordering eye 3
   Two upper labials (3–4 or 4–5) bordering eye. Southern Texas.
   Pituophis deppei deppei (Duméril and Bibron).
3. Dark dorsal saddles on body and tail more than 56.
   Pituophis sayi sayi (Schlegel).
   Dark dorsal saddles on body and tail 56 or less. Eastern Texas.
   Pituophis melanoleucus ruthveni (Stull).

These four species resemble each other in being large, beneficial, non-poisonous, carnivorous, field-inhabiting forms with many dark blotches or saddles on the back.

Arizona elegans elegans (Kennicott)

This snake has been reported from Texas, west of the 98th meridian (Blanchard, 1925, p. 22). A dead example removed from the road 11

[1] Received May 15, 1934.

miles north of Encino, Brooks County, on April 4, 1931, occurred at a point almost precisely on the 98th meridian. It had 31 scale rows at the middle of the body. The United States National Museum has three Texan specimens of this form. The type (No. 1722) from the Lower Rio Grande Valley is faded but well preserved. Two examples from Bexar County were taken at San Antonio (Hurter Coll., May 19, 1908) and Somerset (A. J. Kirn, Mar. 12, 1926) respectively.

Pituophis deppei deppei (Duméril and Bibron)

This form is typically a native of Mexico, but Stull (1932) has indicated that it ranges northward in Texas as far as San Marcos, Hays County.

Pituophis melanoleucus ruthveni Stull

A bullsnake, secured on May 9 on the road near a plot of grass 5 miles southeast of Zavalla, Angelina County (U.S.N.M. No. 83672), in the sandy cut-over pine barren region of eastern Texas, resembled *sayi* of more western and northern areas so closely that it was presumed to be that form until it was identified in the laboratory. Here it was soon found to have the reduced number of dorsal saddles or blotches assigned to "*P. melanoleucus ruthveni*" by Stull (1929), rather than the higher number specified for the form which was termed "*P. sayi sayi*" in the same publication. This led to the identification of the specimen at hand as *ruthveni* (thus introducing the form into the state of Texas) and to a charting of the characters of the several bullsnakes from the critical region in Texas and Louisiana to see if an implication of continuous and progressive geographical variation might be drawn for these snakes. The following table presents these data:

TABLE 1.—VARIATIONS OF PITUOPHIS IN EASTERN TEXAS AND IN LOUISIANA

Locality	La. (type) Rapides Parish	La. (paratype) Rapides Parish	Texas Angelina Co.	Texas Ellis Co.	Texas Clay Co.
Scale formula	31–33–25	31–31–22	31–28–21	31–33–25	31–33–25
Ventrals	219	218	213	223	215
Caudals	59	60	56	62	56
Labials	9-8/15	8/14	9-8/13-14	8/12	9/13
Postoculars	4	3	2–3	3	3
Dorsal saddles on tail	9	?	10	12	12
Dorsal saddles on body	41	?	42	48	54
Total saddles	50	?	52	60	66

Before discussing the taxonomic significance of the above data, attention is called to the geographical position of each of the individuals concerned. The type and paratype of *ruthveni* are from Rapides Parish, central Louisiana, and the additional specimen of *ruthveni* is

from Angelina County, eastern Texas, in a line almost directly west of the type locality. The specimen of *sayi* from Ellis County, Texas, is from a point east of the previously known range of *sayi* and in this way it represents the closest known geographical approach of the range of *sayi* to the range of *ruthveni;* whereas the example of *sayi* from Clay County, Texas, is near the previously known eastern border of the area occupied by *sayi*, but yet far enough north to be considered as more nearly representative of the typical form. Here, then, we find a fine geographical range of specimens arranged in a line from central Louisiana to north-central Texas.

From the standpoint of scutellation, the table reveals no particularly significant differentiation between the eastern and western stocks, even the type specimens of *ruthveni* having the exact scale formula of examples of *sayi* from Ellis and Clay counties, Texas.

But, from the standpoint of the color pattern, with specific reference to the number of dorsal saddles (which seems to be the only significant criterion advanced in the original diagnosis of *ruthveni* for its separation from *sayi*), there is a definite correlation. Originally the gap between *ruthveni* and *sayi* appeared to be wide—perhaps a matter of 15 dorsal saddles as obtained in comparing the extremes in the above table (50 to 66 saddles) but, in parallel with the development in many similar cases, additional specimens from intervening areas here greatly reduce the known differentiation between the two populations. Thus, we find that the known number of dorsal saddles is raised two in *ruthveni* by the specimen from eastern Texas (52 saddles) and lowered six in *sayi* through the example from Ellis County, central Texas (60 saddles); and the fact that this leaves a gap of only seven saddles between the diverging extremes concerned bears taxonomic significance in making it obvious that *ruthveni* and *sayi* must ultimately be ranked as subspecies[2] of each other and that therefore the taxonomy indicated in the original description of *ruthveni* must be changed in some way.[3] Published data of intergradation between *ruthveni* and a subspecies of *melanoleucus* have not been advanced, although Mr. Percy Viosca, Jr., has informed me that certain eastern Louisiana specimens that he has seen are approximately intermediate

[2] Speaking generally from what is known of the variation of other herpetological forms in this region (particularly those of the genera *Lampropeltis, Masticophis, Tantilla* and *Cnemidophorus*), it seems logical to assume that the collecting of additional bullsnakes in eastern and central Texas will enable us to bring these significantly approaching extremes of variation in two subspecies of *Pituophis* closer and closer together, thus ever more definitely revealing the somewhat superficially concealed intergradation between them.

[3] This view has been expressed by Dr. Frank N. Blanchard in a written communication.

between *ruthveni* and *lodingi*. If this is revealed and if *lodingi* in its turn intergrades with the true *melanoleucus* that occurs still further east, a whole chain of geographical races or subspecies of the long known *melanoleucus* will be placed in evidence. Such action is not unlikely. The ultimate series may include the following forms: *melanoleucus*, *mugitus* (southern Florida), *lodingi* (Alabama and probably Mississippi), *ruthveni*, *sayi* and *affinis* (west Texas). Pending the appearance of data contained in Dr. Stull's forthcoming revision of the genus *Pituophis*, and also in anticipation of further field work in eastern Texas and in Louisiana, the present writer feels that nothing is to be gained by making a nomenclatorial change here in the proposed status of either *ruthveni* or *sayi*.

Pituophis sayi sayi (Schlegel)

Several representatives of this form were collected near grassy areas from whence they had wandered to cement pavement to be killed by passing automobiles. Data pertaining to some of these individuals have been presented and interpreted above under *ruthveni*, which appears to intergrade with this form. The following U.S.N.M. and personal records of *sayi* are available, including that of the type (No. 1540) and a paratype (No. 1541) of the synonymous *mcclellanii* from Deaf Smith County. Reports are by counties.

BORDEN: Gail (Vernon Bailey). CARSON: 6 mi. W. Groom (May 28, 1934). CLAY: 1 mi. N. W. Jolly (Apr. 18, 1931). CROSBY: 2 mi. N. W. Crosbyton (Luther Hoyle, June 13, 1933). DEAF SMITH: Red River Valley (R. B. Marcy and Geo. B. McClellan, June 28, 1852). DONLEY: Jericho (May 28, 1934). ELLIS: 1 mi. N. W. Waxahachie (May 26, 1931). FOARD: 3 mi. N.E. Thalia (Luther Hoyle, June 11, 1933). GRAY: 1 mi. W. Alanreed (May 28, 1934). MOORE: Dumas, and 1 mi. N. Etter (May 28, 1934). PECOS: 12 mi. N. E. Ft. Stockton (Luther Hoyle, June 16, 1933). POTTER: 8 mi. E. Amarillo (May 28, 1934). PRESIDIO: Paisano (Wm. Lloyd, July 21, 1890). REEVES: 1 mi. S. Red Bluff (Aug. 12, 1934). SHERMAN: 3 mi. S. W. Texhoma, and 2 mi. N. E. Stratford (May 28, 1934). VAL VERDE: Cave, 20 mi. N. Comstock (J. H. Gaut, May 9, 1903).

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SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

National Academy of Sciences.—Dr. WILLIAM WALLACE CAMPBELL retired from the presidency of the National Academy of Sciences on the expiration of his term of service and Dr. FRANK RATTRAY LILLIE, elected president at the Annual Meeting of the Academy, assumed his duties as President on July 1, 1935.

National Bureau of Standards.—The Edgar Marburg Lecture for 1935 was delivered by Dr. L. B. TUCKERMAN of the National Bureau of Standards before the American Society for Testing Materials in Detroit on June 26.

Doctor TUCKERMAN spoke on aircraft materials and testing, confining himself to the relations between the mechanical properties of the material and the design of parts. Future improvements in aircraft will come through better designs, rather than through stronger materials, because present designs can not utilize the full strength of materials already available.

Dr. W. F. MEGGERS, chief of the spectroscopy section, attended the meeting of the International Astronomical Union in Paris, July 10–17. Doctor MEGGERS is a member of the committee on wave lengths and most of his time was occupied in the work of this committee.

Dr. H. C. DICKINSON attended the 30th anniversary summer meeting of the Society of Automotive Engineers, at White Sulphur Springs, West Virginia, June 16–21. While there he exhibited a new design of "Ride-Meter" or indicator for determining the riding qualities of automobiles. The ride-meter in its present form consists essentially of a pneumatic cushion, and record is made of the total amount of roughness experienced in any given trip. Doctor DICKINSON also exhibited a wobble-meter, jointly designed by himself and Mr. R. W. BROWN and Dr. F. A. Moss, used to determine the fatigue reactions of passengers after riding in automotive vehicles.

To determine how winds stress large buildings, National Bureau of Standards scientists have built a model of the world's highest structure, New York City's Empire State Building, and several blocks of its surrounding buildings. Subjected to regulated and artificial breezes in a 10-foot wind tunnel, this miniature Manhattan gives information that will allow engineers to design buildings that are safe in high windstorms with due regard to least possible cost.

Children's Bureau.—In response to numerous requests, the Children's Bureau made estimates as to the number of children removed from industry by the NRA codes. Employment-certificate statistics collected by the Children's Bureau indicate that in 1929 more children left school to go to work than in the previous year. By 1930, however, when the depression had begun, there was a drop of 46 per cent in the number of boys and girls going to work in manufacturing and mercantile industries. Between 1930, when the last Census was taken, and 1933, when the codes went into effect, there was a further drop of at least 50 per cent. On the basis of the 1930 census figures it is estimated that in that year between 120,000 and 150,000 children under 16 were gainfully employed in the occupations later affected by the 16-year age minimum of the codes. The textile industry alone employed approximately 20,000 children; the clothing industries nearly 9,000; and other branches of manufacturing something less than 40,000. Another 8,000 were

employed in hotels and restaurants, beauty parlors, and laundries; 28,000 were employed in mercantile establishments.

The higher age set by some codes for employment of minors in hazardous occupations affected some young people over the general code age of 16. Over three-fourths of the codes fixed 18 as a minimum age for employment in hazardous occupations. According to the 1930 census 12,000 minors between 16 and 18 were employed in saw and planing mills alone. The lumber and timber products code prohibited their employment under 18. Approximately 5,000 16-year-old laundry workers were removed from hazardous employment through the 17-year minimum of the laundry code. It is roughly estimated that 50,000 16- and 17-year-old minors were prohibited from hazardous employment by the NRA code regulations.

Bureau of Fisheries.—In recognition of his scientific record in the Bureau, Western Maryland College conferred upon J. R. MANNING, chief technologist, the degree of Doctor of Science.

Dr. P. S. GALTSOFF left Washington in June to establish headquarters at the United States Fisheries Biological Laboratory, Woods Hole, Mass., for the conduct of oyster pest control investigations during the coming summer.

WILLIAM HAGAN, JR., was transferred recently from the Division of Fish Culture to the Division of Scientific Inquiry to take charge of field investigations on oyster pest control on the eastern shore of Virginia. Mr. HAGAN will be in charge of the U. S. S. Kittery, which will serve as quarters for a considerable number of men detailed to drill control studies by the Transient Rehabilitation Camp at Fort Eustis, Va.

Dr. WILL M. F. THOMPSON, director of scientific investigations for the International Fisheries Commission, United States and Canada, who has been directing research on the Pacific halibut since the establishment of the Commission, visited the Bureau of Fisheries and conferred extensively with the Bureau's scientific staff at Cambridge, Mass., engaged in North Atlantic fisheries investigations, en route to the annual meeting of the International Fisheries Commission at Ottawa.

National Park Service.—Assistant Director H. C. BRYANT left Washington headquarters late in June for a tour of inspection of a number of the national parks and monuments in the West.

Dr. J. VOLNEY LEWIS, geologist connected with the Service's Naturalist Division, has just completed a monograph on caves and caverns of the United States. Present plans call for the issuance of this work in mimeograph form.

Under the direction of EARL A. TRAGER, Chief of the Naturalist Division, Washington Office, a geological program for the national and state parks has been formulated. Plans call for the setting up of 8 districts, in each of which a geologic technician will supervise and coordinate all geologic projects.

Carnegie Institution of Washington.—Discovery of an orange-red pottery well, from which thirsty Maya Indians drew water centuries ago, is announced by OLIVER G. RICKETSON, JR. The ancient well, which shows how ingenious Mayas stored water, was unearthed at Quirigua, Guatemala, where one of the Mayan cities was located. The well consisted of a pipe of pottery which led down to a big pottery water jar. The jar was buried in stones and sand and served as a cistern. Holes in the jar below the water table permitted free entrance of water.

Conference of state and territorial health officers.—The regular meeting of state and territorial health officers beginning on June 18 considered as its principal business the formation of plans for the expenditure of $8,000,000 provided for in the Social Security bill as a fund for promoting and protecting the health of the nation.

Discovery of a new disease and progress already made toward its prevention were announced simultaneously by Dr. CHARLES ARMSTRONG, of the U. S. Public Health Service, and Lieut. Com. PAUL F. DICKENS, of the Navy Medical Corps. The malady, which has appeared in isolated instances in a number of states, has features resembling meningitis, infantile paralysis, and epidemic encephalitis, or sleeping sickness. The discoverers suggest the scientific name "acute lymphocytic choriomeningitis" for it. The agent causing the disease was found to be a filterable virus. Monkeys, mice and guinea pigs are susceptible to the virus causing the malady, and the two physicians suggest that "a reservoir of the disease may exist in animals." Tests show that a blood serum of patients who have recovered serves to protect experimental animals from the virus, but the serum has not yet been used in human patients to test its power to forestall development of the disease.

Solving problem of photosynthesis.—Announcement was made to a biological conference in Cold Spring Harbor, L. I., by Dr. DEAN BURK, U. S. Department of Agriculture, that he and HANS LINEWEAVER, working in the Bureau of Chemistry and Soils in Washington, have come five steps nearer understanding the baffling chemical processes by which the leaf manufactures carbohydrates. It is now only a matter of time, Dr. BURK said, until several more leaf reactions will be discovered. Dr. BURK compared the reaction of photosynthesis to an endless chain bucket pump in which the sun furnishes the power, the chlorophyll and another catalyst acting as buckets in pumping the carbon products to a higher energy level. The chemical equations he developed depend upon changes of energy content. The Department of Agriculture scientists experimented with a green alga, *Chlorella*, in the life of which little happens except the change of carbon dioxide to protoplasmic carbohydrates.

Giant camera for survey.—The world's largest aerial camera, which can photograph a ground area of 760 square miles, or over twice that of New York City at a single "shot," has been built by Fairchild Aerial Surveys and Aerial Camera Companies for use by the Department of Agriculture in a mapping survey of central New Mexico.

Weighing 275 pounds without films, the camera has ten lenses mounted in two sets of five. When the ten lens shutters are snapped at exactly the same instant by a master electric trigger, ten negatives, making a composite print which measures 32×32 inches, are exposed. Soil Conservation Service workers, starting a survey from the air of the rugged and almost inaccessible terrain of central New Mexico about mid-July, will make first use of the new camera.

Proposed underground water resources survey.—A scientific attack on the drought problem is provided for in a plan for exploring, measuring and charting the underground water resources of the nation, especially in the drought-stricken areas, proposed by the U. S. Bureau of Mines. Application for $1,619,100 of Public Works funds was made by the Bureau for this purpose. Underground water supplies are now badly needed in many parts of the

United States, Bureau officials explain. A systematic survey of the nation's hidden water resources has been recommended by the National Resources Board. Electrical methods of geophysical exploration will be used for locating water and various geological formations in this survey, according to the plans.

Research by Department of Agriculture.—Scientific research that will benefit future generations, as well as the present, is contemplated by a bill introduced in the House by Rep. MARVIN JONES, of Texas. The measure has passed both House and Senate.

According to the terms of the bill, the Secretary of Agriculture "is authorized and directed to conduct research into laws and principles underlying basic problems of agriculture in its broadest aspects," and also to carry on investigations looking to improvements in handling and marketing, as well as "research relating to the conservation development of land and water resources for agricultural purposes."

The research thus contemplated is to supplement, not to replace, other researches now going under the aegis of the Department of Agriculture; but both activities are to be coordinated so far as practicable, and "shall be conducted by such agencies of the Department of Agriculture as the Secretary may designate or establish." The initial funds for this work will amount to $1,000,000. This sum will be increased by an additional $1,000,000 each year until the total reaches $5,000,000, and thereafter the special research fund will be maintained at the latter sum each year. Forty per cent of the total in any year is to be expended under the direct supervision of the Secretary of Agriculture, in any places and for any research purposes he may approve within the scope of the act. The remaining sixty per cent will be prorated among state agricultural experiment stations according to the size of their respective rural populations. Funds thus allocated must be matched dollar for dollar by the states receiving them.

The establishment of new laboratories is within the authorizations of the act, since it is provided that funds may be used for the erection of buildings and the purchase or rental of land needed for the purpose. These laboratories might be set up in the major agricultural regions of the United States, in places designated by the Secretary of Agriculture.

Reporting Hurricanes.—The hurricane weather service of the U. S. Weather Bureau was placed on a decentralized basis on July 1. Instead of the single central office in Washington, three stations have been established in the South, at New Orleans, Jacksonville and San Juan, P.R., respectively. The Washington office will be directly concerned with only such tropical storm centers as move north of latitude 35 degrees, approximately the parallel of Cape Hatteras.

Ships at sea are asked by the Hydrographic Office, U. S. Navy, to radio reports of all hurricanes they may encounter. Radio dispatches may be sent in a special code, obtainable from the Hydrographic Office or from the Weather Bureau. Shore stations "talking" with ships in the neighborhood are authorized to forward to the U. S. Weather Bureau, Washington, by wire collect, information on storms thus received.

NEWS BRIEFS

Dr. HERBERT FRIEDMANN, Smithsonian Institution curator of birds, has made a survey of the forms of bird society reported from all over the world, and concluded that birds that are most advanced evolutionally are also the

most individualistic. Birds that flock together most persistently belong to the more "primitive" zoological groups.

BRADFORD WASHBURN, leader of the National Geographic Society's Yukon Expedition, has returned to Washington after four months in the field to make his report to Dr. GILBERT GROSVENOR, president of the Society. A two-thousand square mile blind spot, in southwestern Yukon Territory, a region of lofty mountain ranges and deep glacier-filled valleys and gorges, has been erased from the map of North America, he said.

Dr. A. G. GILLIAM, Dr. W. P. DEARING and Dr. J. P. LEAKE were sent to North Carolina from the U. S. Public Health Service to assist state and local health officials in fighting an outbreak of poliomyelitis, or infantile paralysis.

PERSONAL ITEMS

Hon. HENRY A. WALLACE, Secretary of Agriculture, was granted the degree LL.D., *honoris causa*, by Harvard University at the June commencement, and also received a similar degree from Columbia University.

Dr. HERBERT F. PRYTHERCH, of the U. S. Bureau of Fisheries, has been elected president of the National Shellfisheries Association and chairman of the State Board of Directors of the North Carolina Fishermans Cooperative Association.

Dr. ISAIAH BOWMAN, chairman of the National Research Council and director of President Roosevelt's Science Advisory Board, addressed the American Association for the Advancement of Science on the value of a proposed program of intensive research on weather records of the past eighty years which he said should be valued "more than all the gold in the Klondike."

Dr. WALTER A. BLOEDORN, of George Washington Medical School, in addressing the meeting of the American Association for the Advancement of Science in Minneapolis, said that iron, one of the oldest medicines in the world, is still one of the most dependable for certain types of anemia.

MRS. KATHERINE K. MADDEN, of Washington, with DR. GEORGE E. SHAMBOUGH, JR., of Chicago, announced at the Cincinnati meeting of the American Federation of Organizations for the Hard of Hearing a plan whereby deaf persons may make postmortem disposal of their ears for the purpose of scientific research.

Fireflies that flash simultaneously in large numbers do not always behave alike. They vary according to species, is the contention of GERRIT S. MILLER, JR., of the U. S. National Museum, commenting in Science on an explanation offered by JOHN BONNER BUCK, of the Johns Hopkins University, for the simultaneous flashing of fireflies over a whole meadow or lawn. Mr. MILLER presented observations made by himself in Jamaica. Here a different firefly species flashes in large groups or "constellations," but these "constellations," though within sight of each other, do not adopt the same flash-rhythm, as observed by Mr. BUCK. Instead, each group is a law unto itself for a time. Then a disintegration of the rhythm sets in, and the flashes come wholly at random.